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(Stated Meeting, held Thursday, October 5th, 1905.)

Reinforced Concrete in Building Construction.

DISCUSSION: Mr. Emile G. Perrot, Mr. Walter Loring Webb, Mr. C. A. Hexamer, Mr. James S. Merritt, Mr. E. P. Cowell.

MR. E. G. PERROT:—In the preparation of the paper which I present to you to-night, it has been my aim to treat the subject from the standpoint of the designer and constructor, giving such data and information as has been found in the writer's experience to be applicable to everyday use; also the general practice of the art throughout the country.

With the constant increasing use of plain concrete in construction and the knowledge of its inherent weaknesses when applied to special forms of construction, it is but natural that the recent rapid development of concrete reinforced with bars of metal distributed throughout the material should have been employed to overcome these weaknesses. So successfully has

this been attained, that the introduction of reinforced concrete marks a new epoch in the history of building, the possibilities of which seem unlimited.

Furthermore, I feel that we are approaching an era where the preference for steel construction fireproofed with terra-cotta or other fireproof material for general building work is likely to be superseded by this more recent construction. To quote from a current periodical, "We cannot measure to-morrow by the yard-stick of yesterday. It takes prophetic insight to lay the lines broad enough and wide enough for the needs of the future, and the world moves so rapidly that even the highest wisdom finds its best calculations none too ample for the requirements of this growing world."

Viewing the great buildings which stand before us to-day as the exponent of that high constructional skill possessed by the Gothic architects, pre-eminent in the list are the French Gothic Cathedrals. These buildings are of masonry, construction solely, and have stood the ravages of time.

But, on the other hand, knowing that the life of steel and iron in construction is a very indefinite quantity, may we not ask ourselves what is to become of the steel skyscraper in the ages to come? As the protection afforded steel or iron imbedded in cement is, for all practical purposes, absolute, is not the logic of reinforced concrete established, and may we not, with much more certainty, secure a permanent construction which will not only outlive steel or iron as generally used to-day, but possesses more truth of expression in art, which is one of the fundamental principles of the great works of the Middle Ages.

Generally speaking, what has been accomplished with the steel skeleton construction is possible in reinforced concrete, and furthermore, if we so will, we can make not only the structural elements of a building of reinforced concrete, but also the ornamental features as well. This, for certain classes of buildings, makes it more desirable as a method of construction, while for the more monumental class, it hardly seems a fitting material in which to carry out any artistic expression.

However, for business buildings and factories, there seems to be no good reason why the exterior walls and ornamentation, such as is used for these structures, should not be built of rein-

forced concrete, our main difficulty at the present being the lack of sufficient knowledge and experience to make a satisfactory finish; although the practice at present seems to tend to a very simple treatment of the concrete, some going so far as to advocate that no further labor be put upon the concrete after the moulds are removed, a proper texture being obtained by well-constructed forms and a proper spading of concrete.

The invention of reinforced concrete is generally attributed to J. Monier, a French gardener, who, in 1868, constructed flower pots with concrete strengthened with a metal network in order to reduce their thickness.

This modest beginning was the starting point of numerous other applications.

At the Paris Exposition of 1855, however, there was exhibited a boat constructed on this system by Mr. Lambot. In America, the first example of this construction was in the year 1874, when W. E. Ward constructed a house of concrete in which the floors were reinforced with bars; but it is to E. L. Ransome that we owe the use of reinforced concrete in this country.

The principle of this construction, as used for supporting members in buildings, is based on the following facts:

Every simple beam, loaded either uniformly over its length, or concentrated at any point thereof, is in compression at the top and in tension at the bottom. By using steel rods of the proper area and at the proper location to resist the tensile stresses, and arranging the concrete so as to resist the compression, the beam will be in equilibrium, as the resistance of concrete in compression is so much greater than it is in tension, the latter being of a low value, no dependence is placed on the concrete to resist the tensile forces, sufficient area of steel being introduced to resist these strains. The force of adhesion between the concrete and the steel is, however, sufficient to transmit the internal stresses across the section of the beam; so that the fundamental principle of the theory of the beam is applicable to this system of construction the same as to a beam composed of a homogeneous material.

I show on the screen a drawing giving ten different methods of reinforced concrete beams. (See Plate I.)

In Fig. 1, we have a simple beam with the reinforcement run-

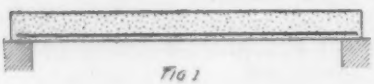


FIG 1

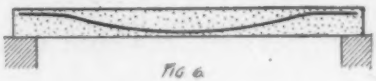


FIG 6

FIG 2

FIG 7

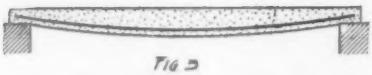


FIG 3

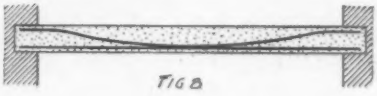


FIG 8

FIG 4

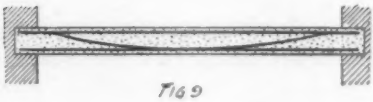


FIG 9

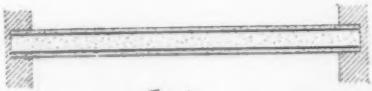


FIG 5

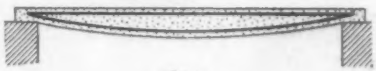


FIG 10

Plate I. Methods of reinforcing concrete beams.

ning in a straight line near the bottom side. This form of reinforcing concrete is more generally used for the slab connecting the beams than the beams themselves.

In Fig. 2, we have the bars curved, being nearer the bottom of the center of the span, where the bending moment is greater, and curving upwards towards the ends, where the bending moment finally reaches zero.

In Fig. 3, we have the steel rods placed as before, and the bottom of the beam curved, following the outline of the rod; this gives the beam a continuous strength, the resisting moment being just equal to the bending moment at every point along the beam.

Fig. 4 shows one method of reinforcing restrained beams; as the ends of the beams are held rigidly in the walls, there is a negative bending moment at the top of the beam near the supports, gradually changing into the positive bending moment at the bottom. The upper rods should be long enough to resist the tension produced on the top of the beam. The point of contraflexure, or where the negative bending moment changes, is about ,21 of the span from the support.

In Fig. 5, the top rods run the entire length of the span; they not only resist the tension near the support, but add to the compressive value of the concrete at the center of the span.

Fig. 6 shows a method by which one rod is made to perform the office of two rods, the rod being bent in such a manner as to take care of both the positive and negative bending moment.

In Fig. 7, the ends of the beams are made deeper and coved; this gives additional sectional area to the concrete where the vertical shear is greatest.

Fig. 8 is a combination of Figs. 1 and 6, and is an admirable disposition of the rods, since the positive and the negative moments are resisted by separate rods, and the straight rods permit of securing stirrups or hangers which run vertically at close intervals to resist the internal shear in the beam. This arrangement is used in the Hennebique System.

Fig. 9 is a fuller development of Fig. 8, but not as extensively used.

Fig. 10 is a development of Fig. 3, having a straight bar in the upper part of the beam; this not only reinforces the com-

pression side of the beam, but also is justified by practical reasons such as those mentioned for the straight rods running the full length of the beam shown in Fig. 8.

For very long spans and special cases of loading, other methods of reinforcing the beam are used, the above illustrations applying to normal conditions only.

Among the numerous patented systems, those most familiar in this country are the Ransome, Kahn, Thatcher, Hennebique, De Valliere, Cummings, Johnson, Columbian, Expanded Metal, Roebling, International, Unit, Visintini, etc.

These may be divided into five classes: (1) Those using "deformed" bars; (2) Those using plain bars; (3) Those using a "webbing;" (4) those using a "frame;" and those in which the parts are moulded in advance and then set in position.

In the first class are the Ransome, which uses a square twisted bar; the Kahn, which uses a square bar with side wings bent upwards to form stirrups; the Thatcher bar, which is a round rolled bar with flattened sections; the Johnson bar, which is square in section and has ridges on the four sides.

In the second class are the Hennebique and De Valliere, in which half the number of bars are bent in the form shown in Fig. 8; the stirrups in the two systems being the points of difference. The Cummings combines the rod and stirrup in one bar. The Columbian uses a specially-rolled bar similar to a double cross in section, and supports it at the ends on steel beams or walls.

In the third class are Expanded Metal; Roebling and International; these employ a netting or sheeting in the concrete slab, in some instances strengthing with rods or cables.

In the fourth class may be mentioned the "Unit" Girder Frame, in which the entire reinforcement is made at a shop and delivered as one piece ready to set in the moulds.

The fifth class is represented by such systems as Visintini, which is moulded in advance, making a complete beam.

The following illustrations show the practical application of the foregoing principles as used in the different patented systems:

EXTRACTS FROM REPORT OF FIRE TEST ON UNIT SYSTEM.

"The superiority of concrete as a fireproof material was again demonstrated in a recent fire, water and load test made in

Philadelphia, June 16th, 1905, on the "Unit" system of reinforced concrete. The test was conducted by the engineering staffs of the Building Bureaus of the cities of New York and Philadelphia, directed by Professor Ira H. Woolson, E.M., of Columbia University, New York, assisted by two students of the University.

The test house, or furnace, was a brick building, 10 ft. 6 in. wide by 19 ft. 6 in. long inside. The clear height from the ground to the bottom of the beans was 10 ft. 6 in. The roof consisted of three concrete beams, 14 in. deep, spaced 4 ft. centers to centers, two beams resting at the ends on 12x12 in. reinforced concrete columns. The middle beams rested on 11x16 inch reinforced girders, which in turn were supported by the columns. The slab was $3\frac{1}{2}$ in. thick.

The columns were reinforced with four $\frac{7}{8}$ in. rods tied together every 18 inches with $\frac{1}{4}$ in. wire ties. The beams were reinforced with a girder frame made up in three different manners. The 11x14 in. beam was reinforced with a girder frame made of $\frac{3}{4}$ inch patented quadruple bar, with $\frac{1}{8}$x1 in. stirrups secured to the bar at intervals of about 12 inches, except at the ends, where they were closer, by means of the prongs struck out of the webs. The middle beam was 9 in. wide and 14 in. deep, reinforced with four $\frac{13}{16}$ in. round steel rods clamped together with $\frac{1}{8}$x1 in. stirrups spaced as in the other beams. The remaining beam was the same size as the middle beam, reinforced with two patented Siamese bars punched their entire length with stirrups clinched thereto by means of the prongs thus formed and spaced the same as in the other beams. The slab was reinforced with $\frac{5}{16}$ in. plain, round rods run at right angles to the beams, spaced every 6 in., with $\frac{5}{16}$ in. round rods run at right angles thereto about every two feet. Additional short rods, $\frac{5}{16}$ in. in diameter were run near the top of the slab over each beam to reinforce this portion and passed through holes in the stirrups. The distance from center to center of the columns was 16 feet. The beams were continuous over the columns, and rested in the end walls. The concrete was hand-mixed: one part of Vulcanite cement, two parts of Jersey bank gravel, four parts of trap rock, $\frac{1}{2}$ and $\frac{3}{4}$ in. size. The steel had an ultimate strength of 60,000 to 70,000 pounds per square inch. The concrete was two months old.

The test slab and beams were to carry a total live load of 30,700 lbs. during the fire test and 122,800 lbs the following day. The average temperature of the fire during the test was 1708.6 degrees F. The maximum deflection of the middle beam under the action of the fire and water was $1\frac{2}{3}\frac{7}{2}$ in. On June 17th, under the full load of 650 pounds per square foot, which by an error was 50 pounds more than the requirements, the deflection was only two inches, which was within one inch of the deflection allowed by the department.

When the total load was removed some two weeks afterwards, it was noticed that the beams had recovered $\frac{3}{4}$ inch of the deflection, showing that the elastic quality of the construction had not been destroyed. The effect of the water under the high velocity and pressure was to cause some of the concrete on the under side of the beams to spall off. The concrete on the girders, columns and slab was undisturbed, except for the small spalling of a corner of two of the columns. An interesting fact developed by the test was the expansion of the four columns from heat. They elongated about one inch and recovered their normal position in cooling."

Plate II shows the load test of 650 pounds per square foot, applied after the fire.

We have here some samples of steel which is embedded in concrete. One sample is taken from the pavement of the City Hall, and shows that the steel was not affected by the elements in any manner, the concrete forming an absolute protection, although this particular piece had been embedded in the pavement for at least nineteen years. The other specimen I show is taken from Binder's pavement, 13th street above Chestnut. This shows the steel in contact with the concrete and the thorough protection afforded by it. This specimen was at least twelve years in the pavement.

I now give you the result of load tests made under my directions last May on four full-size tee-beams having a clear span of twenty feet. These tests were made to determine the strength of this form of beam reinforced with Unit Girder Frames: Plate III shows the cross-section of the beams and Plate IV the method of reinforcing the beams.

Beam No. 1.—One $\frac{3}{4}''$ quadruple unit bar with solid web for 6′ 7″ in center—Area. 2.14 sq. in. See Fig 1, Plate V.

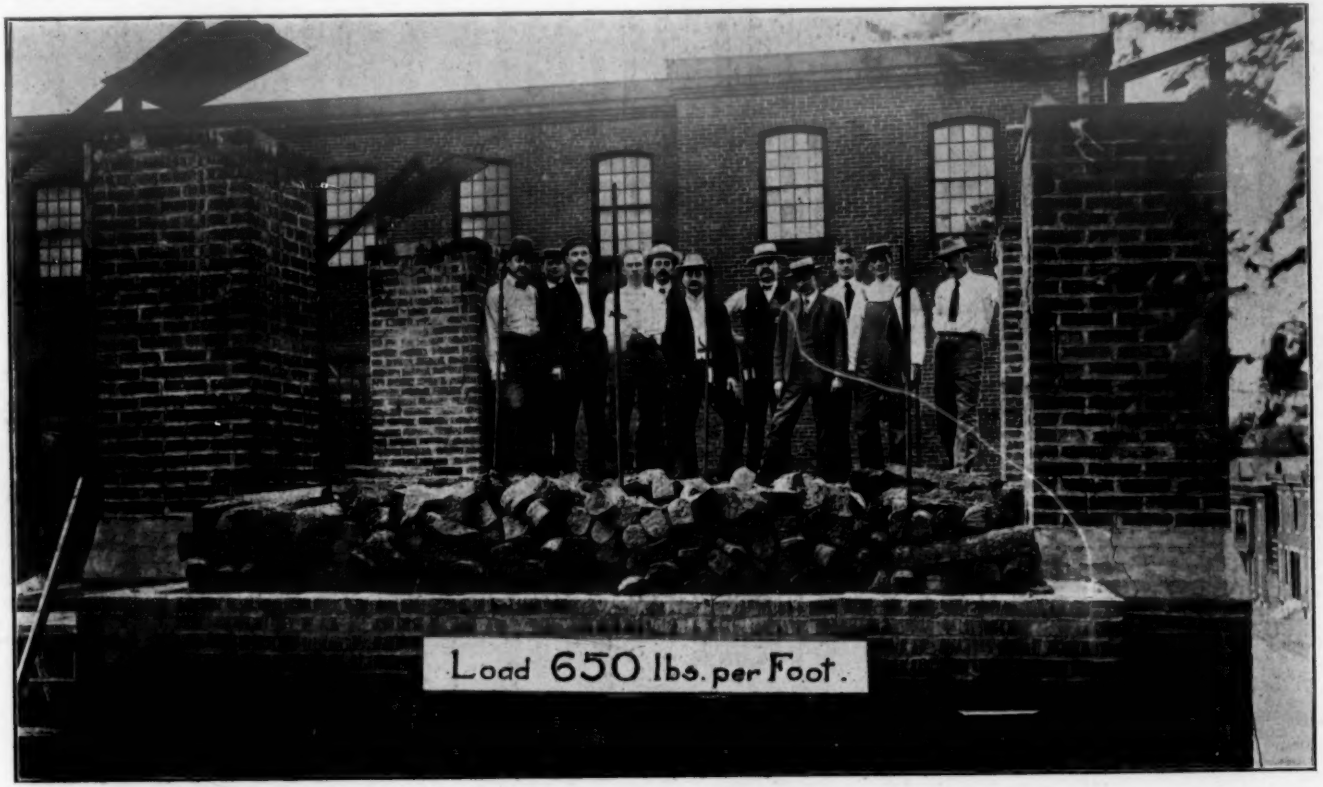


Plate II. Test of floor after fire.

Beam No. 2.—One $\frac{3}{4}$" quadruple unit bar with punched web entire length—Area, 1.86 sq. in. See Fig. 2, Plate V.

Beam No. 3.—Four $\frac{1}{6\,3}$" plain round rods clamped together —Area, 2.07 sq. in. See Fig. 1, Plate VI.

Beam No. 4.—Two $\frac{3}{4}$" siamese bars clamped together, web punched entire length—Area 1.86 sq. in. See Fig. 2, Plate VI.

I have scheduled the results of the tests in the following tables, which show that the Christophe's formula as we have been using it corresponds very closely with the actual conditions found in the tests. See Tables Nos. 1 and 2 of Plate VII.

Table No. 1 gives the necessary data concerning the general composition and physical properties of the materials. Table No. 2 gives the comparison of the actual bending moments to the theoretical bending moment.

By reference to table No. 1, it will be noticed that beam No. 1 failed by the breaking of the bar; beams Nos. 2 and 4 by crushing of the concrete at the top of the beam; and beam No. 3 by the slipping of the rods in the concrete. This slipping is clearly shown in the photograph of the beam, the concrete at the top of the beam being intact. From observations of the tests, it is evident that beams Nos. 1 and 3 possessed nearer the proper proportion of steel to concrete than beams Nos. 2 and 4, and by actual computation, the area of steel required for the Tee section used, is 2.14 square inches. This is based on safe working stresses on concrete and steel of 500 and 16,000 pounds respectively, and is obtained by using formula No. 3, to locate the neutral axis, and then substituting the value of "a" thus found in formula No. 4, which gives the area of the steel required.

The hypotheses assumed in our computations for all beams and girders, while not entirely correct, are sufficiently near the truth for all practical purposes, for, even though they were entirely correct, it would be very difficult to derive a formula suitable for practice which would take into account all the varying conditions of the concrete, such as produced by the age of the mixture, the proportion, the coefficient of elasticity, etc.

The most important hypothesis used in calculating pieces subject to flexure is the conservation of plane sections, since it furnishes the starting point, that two sections originally par-

allel will, after loading, rotate about the neutral plane and remain true planes.

In deducing a formula on the above assumption, we also neglect the effect of the concrete in tension. Some authorities, however, consider the effect of concrete in tension in deducing their formula, but it is better to err on the side of safety and not count the concrete in tension, depending solely on the metal reinforcement to resist tensile strains.

The formula for tee-sections which we have adopted, when the neutral axis falls below the slab, is the same as that employed by Paul Christophe, the celebrated French engineer, changing the ratio of the coefficient of elasticity of the steel and concrete from 10 to 20. If 10 was used, Beam No. 1 would show an excess of strength of 16 per cent. above the formula, whereas the variation when 20 is used, is only 5.6 per cent., showing this ratio to be nearly accurate.

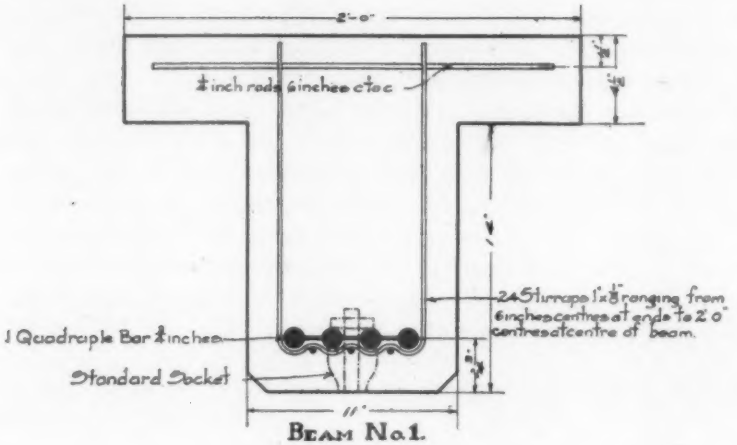
$$M=\frac{p}{6\ a}\left[a^2w\ (3h'-a)-(a-g)^2(w-e)\ (3h'-a-2g)\right] \quad (1)$$

p=the unit compressive strain on the concrete.
e=the width of the beam or rib.
a=the distance from the neutral axis to the most remote fibre in compression.
w=the width of the slab.
h′=the distance from the top of the slab to the center of action of the reinforcement.
g=the thickness of slab.
t=safe unit stress on steel.
S=area of steel.

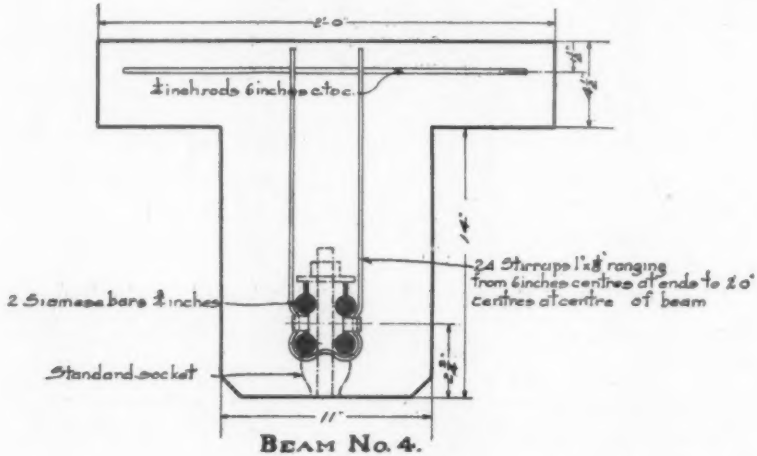
The position of the neutral axis, (a) is found by the following formula, after which it is inserted in the formula for bending moment:

$$a=-\frac{1}{e}[g(w-e)+m\ t]+\sqrt{\frac{1}{e^2}[g(w-e)+m\ t]^2+\frac{2}{e}\left[\tfrac{1}{2}g^2\ (w-e)+m\ t\ h'\right]} \quad (2)$$

This method is applicable when the area of the steel is determined upon in advance. Where the area of the steel is to be found, having the exterior dimensions of the concrete given, the formula for the position of the neutral axis may be simplified considerably when the two materials are considered to be

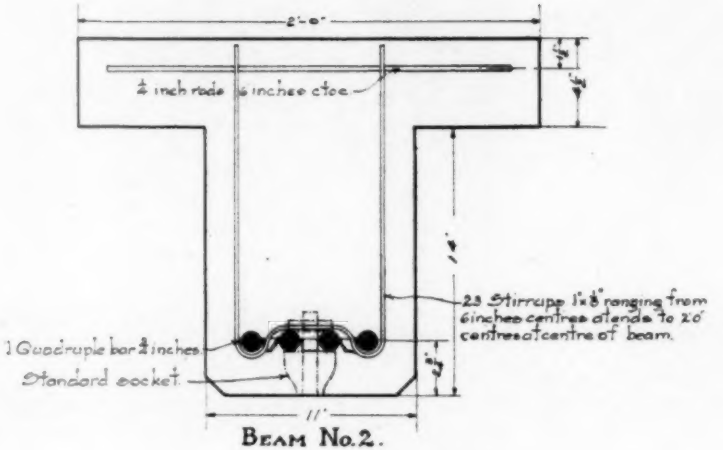

2'-0"
¾ inch rods 6 inches c to c
24 Stirrups 1"x⅛" ranging from 6 inches centres at ends to 2'0" centres at centre of beam.
1 Quadruple Bar ¾ inches
Standard Socket
11"

BEAM No. 1.

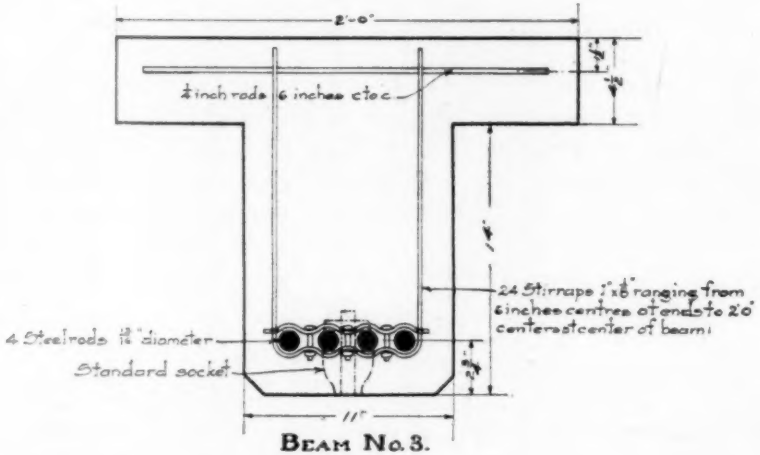

2'-0"
¾ inch rods 6 inches c to c
24 Stirrups 1"x⅛" ranging from 6 inches centres at ends to 2'0" centres at centre of beam
2 Siamese bars ¾ inches
Standard socket
11"

BEAM No. 4.

Plate III. Cross-sections

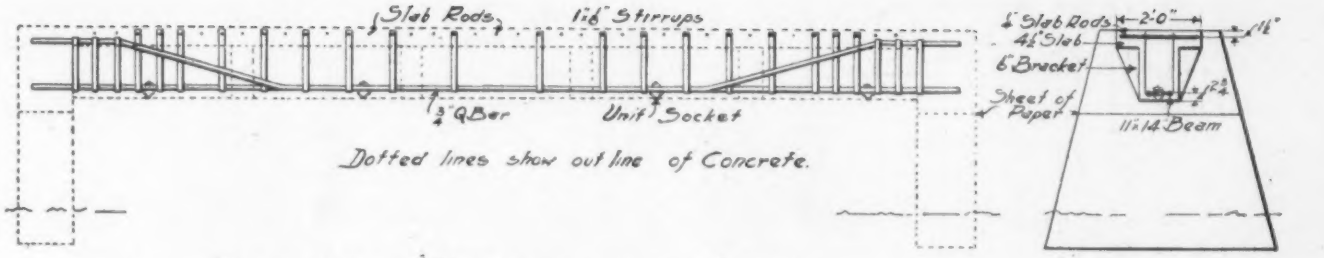

2'-0"
¾ inch rods 6 inches c to c
23 Stirrups 1"x ¼" ranging from 6 inches centres at ends to 20" centres at centre of beam.
1 Quadruple bar 2½ inches
Standard socket
11"

BEAM No. 2.


2'-0"
¾ inch rods 6 inches c to c
24 Stirrups 1" x ¼" ranging from 6 inches centres at ends to 20" centres at center of beam
4 Steel rods 1¼" diameter
Standard socket
11"

BEAM No. 3.

of T-beams.



ELEVATION OF REINFORCEMENT OF BEAM

CROSS SECTION.

Plate IV.

stressed to their assumed values, both being stressed their proportional part, so that neither one is doing more work than the other. The formula then becomes—

$$a = \frac{h'}{1 + \frac{t}{pm}} \qquad (3)$$

Having obtained the value "a" in this formula, it can be substituted in Formula 1. This will give the strength of the beam.

The area of the steel to develop this strength is found by the following formula:

$$S = \frac{a^2w - (a - g)^2(w - e)}{2m\,(h' - a)} \qquad (4)$$

The safe working stress of the concrete I have assumed at 500 pounds per square inch and of the steel 16,000 pounds per square inch, these values being established by the Philadelphia Bureau of Building Inspection. This gives a factor of safety of four on the construction, as by multiplying the bending moment so obtained by four we obtain the breaking moment of the beams as shown in the table.

The approximate formula for finding the area of the steel in the bottom of a beam of tee-section, while not being entirely correct, is very convenient for checking-up purposes, and where absolute refinement is not necessary. It is based on the principle of the moment of a couple, taking the lever arm as the distance between the center of action of the steel and the center of the slab, the formula becomes—

$$S = \frac{M}{16000 \times (h' - g/2)} \qquad (5)$$

That is, the area of the steel, S, = the bending moment in inch pounds, divided by 16,000 times the distance from the center of the center of action of the steel to the center of the concrete slab.

I have called this in Table No. 2 the plate girder formula.

It is interesting to note the deflections which are shown by the following diagram. See Plate VIII.

Fig. 1.

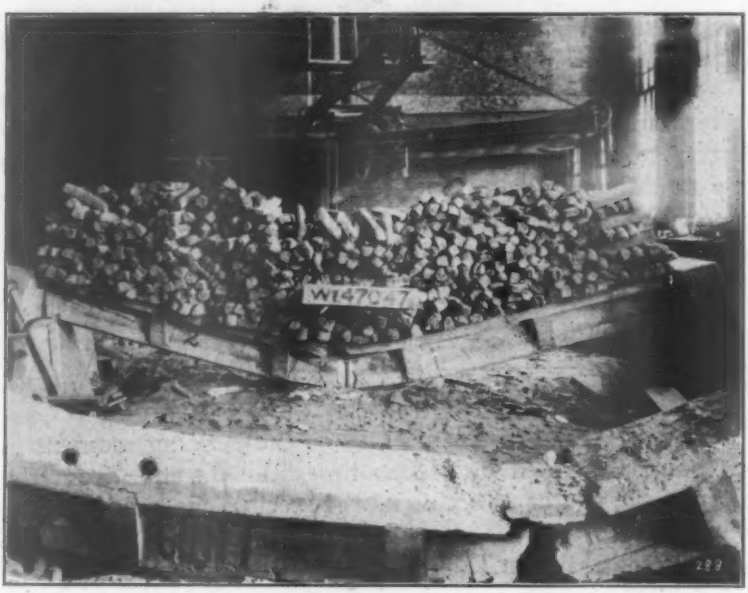


Fig. 2.
Plate V. Breaking loads on T-beams.

PLATE VII—TESTS OF REINFORCED CONCRETE "T" BEAMS.

TABLE NO. 1.

No.	No of Tests	Clear Span	T. BEAM	CONCRETE: Mixture †	Age in Days	Total Weight of Beam	Compression on 6" Cube lbs. per sq. in.	$E_s - E_c$	STEEL: Strength lbs. per sq. in.	Elastic Limit	Tension Allowed	Test Piece	Diameter	Area of Steel to Concrete	Reduction of Area at Center	Reduction of Area at Break	a. Neutral Axis	LOADS: Calculated Safe Load	Load * Producing First Crack	Actual * Breaking Load	REMARKS
1	1	Ft. 20	1-¾" Q Bar Solid Web	1—2—4	75	5820	3000	20	65800	40200	16000	1	¾	.92 of 1%	%	% 20	6"	Total 16056 Live 11236	‡ Def. 3/16" Load 28980	60688	Rods broke at the end of solid web, distance about ⅓ span.
NO. 2																					
1	1	20	1-¾" Q Bar Punched Web	1—2—4	77	5820	3000	20	63400	39400	16000	1	¾	.8 of 1%	8½		5.68"	Total 15375 Live 9555	Def. ¼" Load 26225	52867	Concrete crushed.
NO. 3																					
1	1	20	4 Plain Steel Rods 1 3/16"	1—2—4	78	5820	3000	20	73300	53800 55500	16000	2	1 3/16	.89 of 1%	7½ 3.8		5.92"	Total 15909 Live 10089	Def. 5/16" Load 26322	64227	Rods slipped, two rods broke at about ¼ the length of span from the end due to impact when beam dropped.
NO. 4																					
1	1	20	2-¾" Simese Bars Punched Web	1—2—4	79	5820	3000	20	62550	37300	16000	1	¾	.8 of 1%	Upper 5½ Lower 11		5.68"	Total 15375 Live 9555	Def. 3/16" Load 20195	52899	Same as No. 2.

NOTE—* Load includes weight of beam.
† Hand mixed stone ¼ and ¾ inch size.
‡ Def. indicates deflection at center of beam.

TABLE NO. 2

Beam	A. Actual Center Bending Moment	B. Resisting Moment Christophe Formula	C. Resisting Moment Plate Girder Formula, based on 64,000 lbs.	D. Resisting Moment Plate Girder Formula, based on test strength	Variation Per Cent	Variation Per Cent.	Neutral Axis	Calculated Bending Moment at end of web	Deflection at instant of failure	Area Steel
No. 1	1820640	1928764	1848960	1900962	A 4.2 % less than D.	A 5.6 % less than B.	6"	1608400	8 13/16"	2.14 sq. in.
No. 2	1586010	1844972	1607040	1591974	A 4 % less than D.	A 14 % less than B.	5.68		16 3/16"	1.86
No. 3	1926810	1909056	1788480	2048368	A 6 % less than D.	A 9 % greater than B.	5.92		11 5/8"	2.07
No. 4	1586970	1844972	1607040	1570630	A 1 % greater than D.	A 14 % less than B.	5.68		18 3/16"	1.86

Ratio of Strength between No. 3 and No. 1.

The steel in No. 3 was 11 % stronger than that in No. 1 by actual tensile test, and had 33 % greater elastic limit, but the beam was only 5.8 % stronger by actual load, this small increase being due to the rods slipping. In No. 1 the solid web should have been at least 7′ 3″ long; instead it was only 6′ 7″. The resisting moment at the ends of the web just equaled the bending moment at these points. This is where the rods broke, so that the strength of the bar at center of beams was not fully developed.

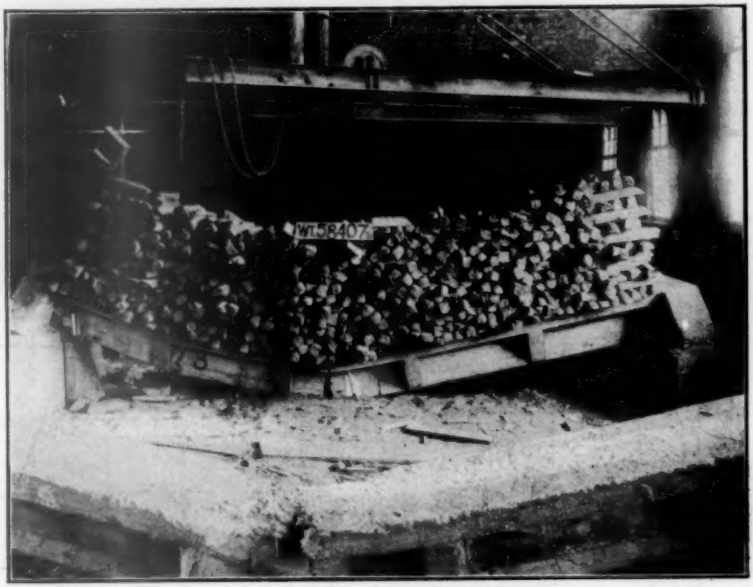


Fig. 1.

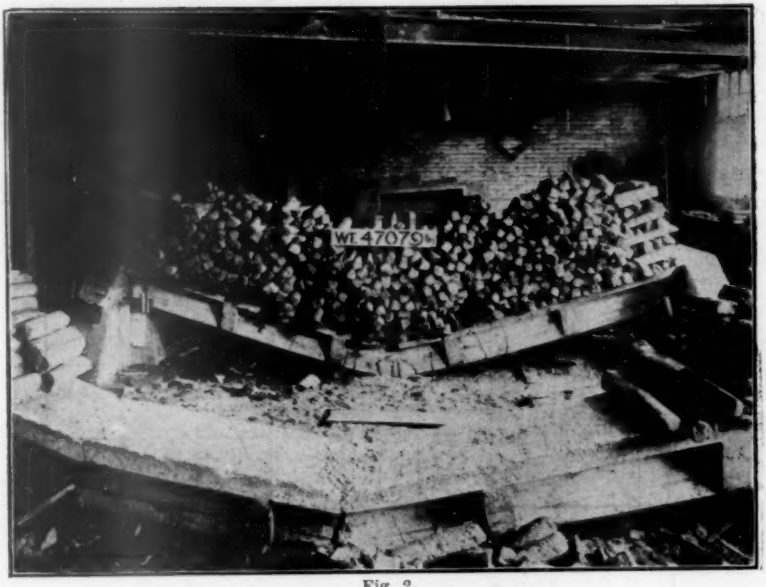
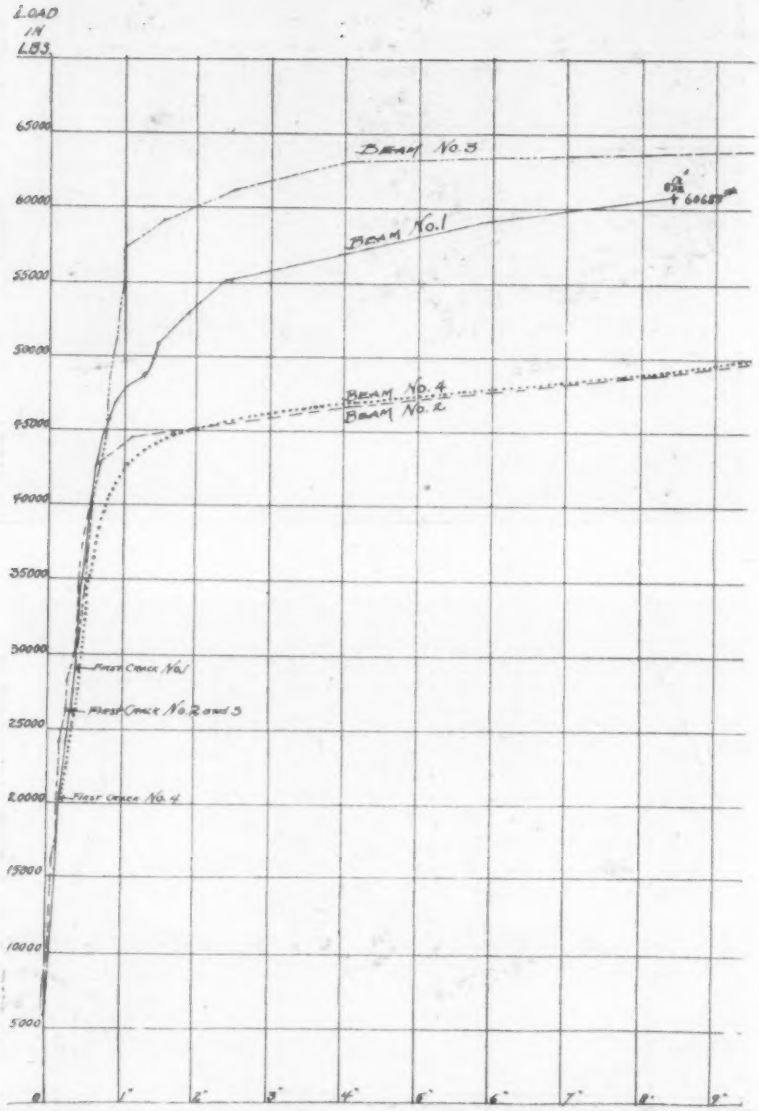
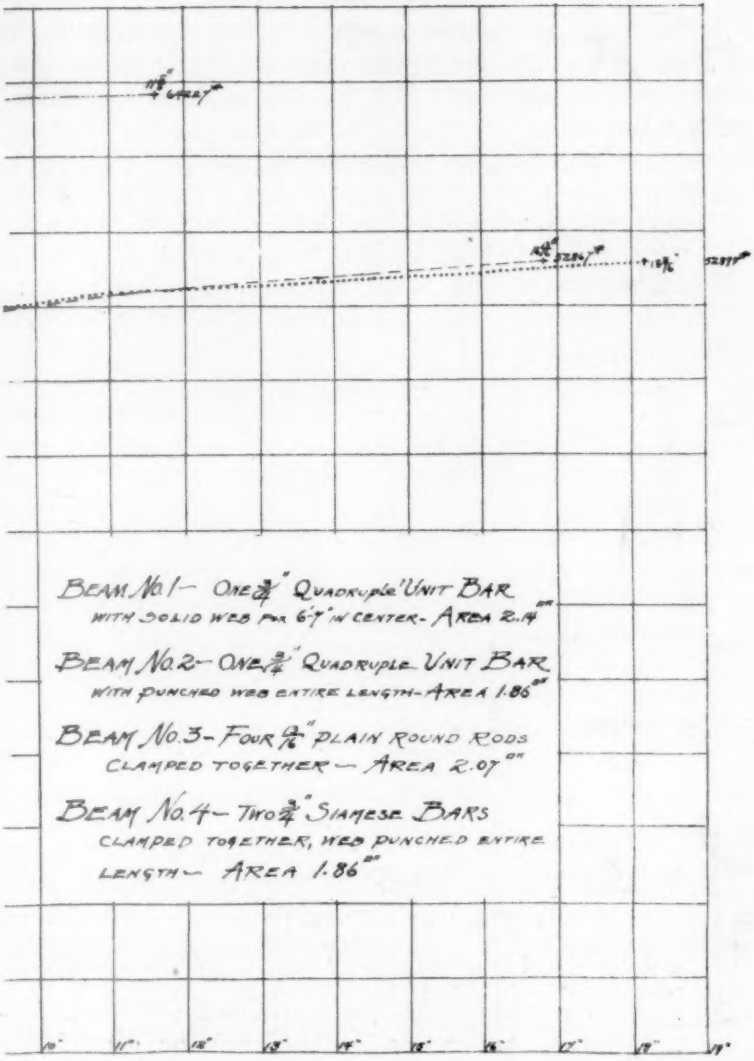


Fig. 2.

Plate VI. Breaking loads on T-beams.


LOAD IN LBS.
65000
60000
55000
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1"
2"
3"
4"
5"
6"
7"
8"
9"
BEAM No. 3
BEAM No. 1
BEAM No. 4
BEAM No. 2
First Crack No. 1
First Crack No. 2 and 3
First Crack No. 4


BEAM No. 1 — ONE 3/4" QUADRUPLE UNIT BAR
WITH SOLID WEB FOR 6'-7" IN CENTER — AREA 2.14 SQ. IN.
BEAM No. 2 — ONE 3/4" QUADRUPLE UNIT BAR
WITH PUNCHED WEB ENTIRE LENGTH — AREA 1.86 SQ. IN.
BEAM No. 3 — FOUR 9/16" PLAIN ROUND RODS
CLAMPED TOGETHER — AREA 2.07 SQ. IN.
BEAM No. 4 — TWO 3/4" SIAMESE BARS
CLAMPED TOGETHER, WEB PUNCHED ENTIRE
LENGTH — AREA 1.86 SQ. IN.

I show a number of illustrations of different methods of constructing high buildings, giving the comparison between the steel skeleton construction and the concrete skeleton construction; also pier construction in concrete and monolithic wall construction.

Various methods have been used to secure overhead shafting, fixtures, etc., by using some form of bolt or socket built in the concrete beam, but not coming in contact with the steel reinforcement, except in the case of the Unit system, where a specially-designed socket and stud is used as shown in the previous illustrations. This socket forms a part of the system and is used whether it is intended to secure overhead fixtures or not. The following views show some of the adaptations of how this socket is used to secure shafts and pipes.

The rigidity of reinforced concrete buildings is very much greater than that of any other known form of construction. The following views show the engines of the Victor Talking Machine Company, which are supported on reinforced concrete. A coin can be placed upon the cylinder of the engine and will remain there indefinitely, showing that the floor construction is so rigid as to prevent any local vibration; although it is noticed that a building of this character will rock or move as a whole, being perceptible in the top stories of such buildings; the action being somewhat in the nature of the vibration of a small end of a whip when held vertically.

[The speaker showed a number of illustrations descriptive of some of the work done throughout the country by various engineers, including the Government engineers, who have found this construction to be very suitable for the various types of buildings they design, this method of construction being largely used by them.]

Mr. Walter Loring Webb:—So much has been said, written and published during the last few years in regard to reinforced concrete that it is unnecessary in a short address on this subject to review the history of the development of reinforced concrete or even to attempt to establish any of the fundamental equations which are in most common use. I will therefore devote my time to a few remarks on certain phases of this work where comment seems necessary.

ELASTIC LIMIT OF METAL.

It is generally admitted by experts that the elastic limit of the metal is the virtual ultimate of the strength of a reinforced concrete structure, but the exact meaning and application of this statement is not thoroughly understood by many. In an ordinary steel bridge, which consists of but one kind of material, a stress in the structure which momentarily exceeds the elastic limit may produce a small but permanent deformation but will

Section of concrete-steel curtain dam.

not cause failure and is not immediately dangerous. Therefore the working stress may properly be permitted to approach the elastic limit much nearer than should be allowed in reinforced concrete. To put it in figures—in a bridge or a building the working stress of 16,000 lbs. is frequently permitted in metal, which has an elastic limit of 30,000 or 32,000 lbs, and an ultimate of 60,000 lbs. Experience has shown this to be safe. If a concrete structure is reinforced with this same grade of metal the same working stress of 16,000 lbs. has by no means

the same *real* factor of safety that it has in the case of the steel stress, for as soon as the loading is actually increased (perhaps accidentally) to twice the working load, the structure will be at the point of actual failure. The steel will not return to its former position with reference to the concrete, and therefore the union between the concrete and the steel will have become destroyed. This is especially true if the bar is a plain bar in which the union between the concrete and the steel depends entirely on adhesion. Since the strength of a reinforced concrete structure is absolutely dependent on the intimate union of the concrete and the steel, the structure must be at the point of failure as soon as that union is destroyed. The accuracy of the above statement has sometimes been attacked by a comparison of the breaking loads of reinforced concrete beams which have been variously reinforced with plain bars, deformed bars and bars of a high and low elastic limit steel. Such tests are of almost no value for the determination of this point unless the bars of high and low elastic limit are otherwise identical. On account of the security to the union of the concrete and steel which is afforded by a deformed bar, this quality is perhaps of greater importance than the elastic limit, and it is quite probable that a plain bar with high elastic limit will have but little, if any, advantage over a deformed bar with low elastic limit, but the combination of a deformed bar with a high elastic limit gives the best form of reinforcement that can be made.

The building ordinances of cities, which have generally been written on the basis of ordinary steel construction, have been applied without any change to reinforced concrete work. This is sometimes due to the fact that inspectors have been compelled, by the literal statement of the existing building law, to follow obsolete specifications. But even this excuse does not apply to Philadelphia, which acts under a building law which was amended in April, 1903. This amendment recognizes reinforced concrete as a special method of construction and prescribes a few regulations regarding it, but these regulations are utterly inadequate and defective. Some of these regulations are not in accordance with the principles now generally recognized in reinforced concrete construction. In other respects they are inadequate and the saving clause is introduced of requiring that the plans shall have the approval of the building

inspectors. Such a regulation may be all right as a makeshift, but the same reasons which justify the present elaborate details of the building law on very minor details should require a properly designed code of regulations which will enable designers to know what designs will be acceptable by the department. The initial stresses in the concrete, due to its contraction during setting, are usually ignored by designers. Tests have shown that such stress may, under some conditions, be as great as that due to the working load. The Johnson-bar sys-

Section of concrete-steel breast dam. For soft foundation and low head.

tem is based on the use of steel with an actual elastic limit of about 60,000 lbs. For calculations this is reduced to 50,000 and a factor of *four* is then used for a working stress of 12,500. Compare, for an instant, the relative safety of such a system with that of permitting a working load which will produce a stress of 16,000 lbs. in the steel, plus the unknown stress due to contraction of the concrete, when the steel is of such quality that a stress of only 30,000 lbs. will cause failure. The building laws of Philadelphia permit this very construction, and

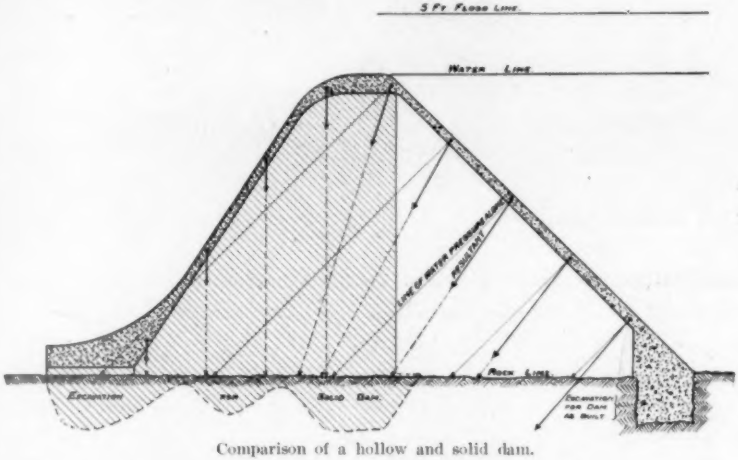
it is frequently used. It will be surprising if failure does not occur in structures built in this way.

REINFORCED CONCRETE DAMS.

One of the most remarkable applications of reinforced concrete is its use for the construction of dams. Omitting from consideration the very few dams, which on account of their exceptional location are constructed on the arch type, dams can be divided for the present purpose into two general classes. In one class the upstream face of the dam is so nearly vertical that the pressure of the water produces a tendency to overturn about the toe of the dam. The higher the flood the greater will be the overturning moment. This is resisted by the weight of the dam, which has a resisting moment in the contrary direction. The ratio of the resisting moment to the overturning moment constitutes the factor of safety of the dam. Such dams are usually built of solid masonry so as to furnish the necessary dead weight, and yet such is the cost of masonry that its volume in the design is reduced to the lowest limit which prudence can tolerate, and then some unusual flood or a weakening of the foundations will make the factor of safety (perhaps 2 or 3) insufficient and the dam gives way. The other type, of which a timber dam is the most common example, has an upstream face which makes an angle of less than 45° with the horizontal. In such a case the center of pressure of the dam is within the base of the dam. There is, therefore, no tendency to overturn. The higher the flood the greater will be the downward pressure and the greater will be the horizontal component tending to sweep the dam downstream, but the dam cannot possibly overturn. A solid masonry dam with such an outline would have a prohibitive cost. A timber dam has but a short life and a considerable maintenance charge even while it is being used. An earth dam is unreliable, especially if it has no core-wall, and if it has a thoroughly reliable core-wall it is expensive. A reinforced concrete dam is built with a comparatively flat upstream surface, so that there is never any tendency for it to overturn. Its cost is considerably less than that of a solid masonry dam. It is but little, if any, more expensive than a well-built wooden dam, and the adoption of this method has frequently permitted the utilization of water power

sites which otherwise could not have been utilized without an expenditure which would not have been justified by the income.

The comparison of a hollow dam and a solid dam are illustrated in sectional view showing the actual designs made for a given location. The relative amount of masonry, the relative excavation for the foundations and the relative pressures with their resulting actions on the dam are illustrated in this figure. The limits of this article will not permit the elaboration that the subject deserves, but a few points which are easily realized from the figures here shown will be briefly stated.



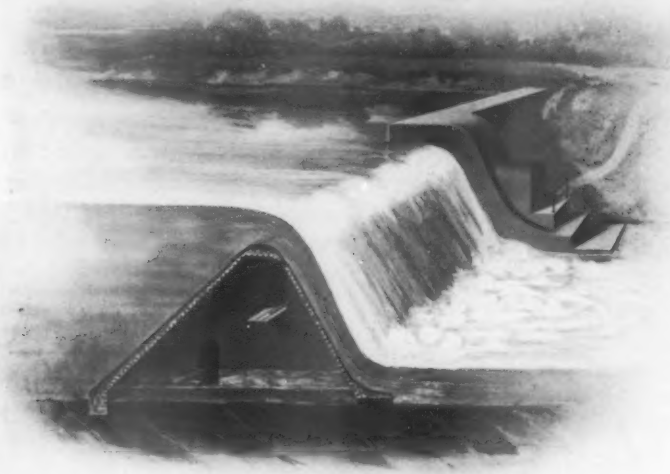
Comparison of a hollow and solid dam.

First, there is practically no danger that the dam will be swept down stream and absolutely no possibility of its being overturned.

Second, a reinforced concrete dam is "bottle tight" from the start and it remains so. This fact is easily verified by inspection, because the dam is hollow, and if by any possibility any leaks should occur they are easily repaired at a very small expense.

Third, the upward hydrostatic pressure which reduces the stability of an ordinary solid masonry dam is totally absent, for, if the soil is all porous, weep-holes are purposely made in the bottom of the dam so as to eliminate any such tendency.

Fourth, the base of these dams is so broad that a dam may be located on a soft bottom under circumstances which would be



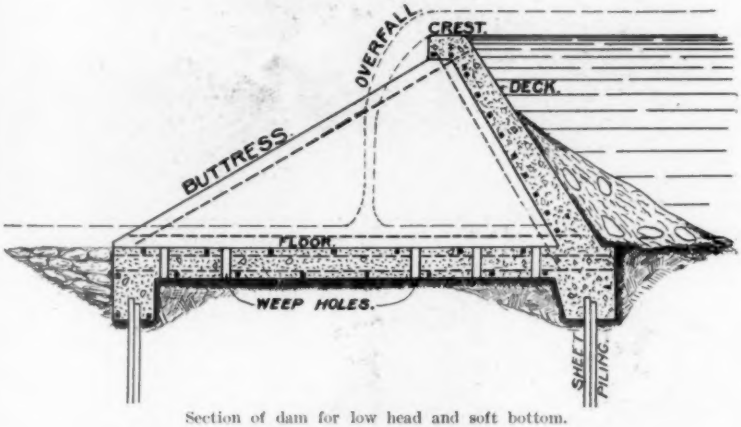
Section of concrete-steel apron dam. For rock foundation and high head.

Section of concrete-steel apron dam. For clay or gravel foundation and high head.

prohibitive except at enormous expense for a solid masonry dam.

Fifth, a wooden dam is never any better than on the day it is finished. Its deterioration commences from that day. A concrete dam, on the contrary, gains steadily in strength. It becomes part of the geology.

Sixth—*Effect of Ice.*—Many a dam of solid masonry has been carried out by the pressure of a great ice gorge. Even a wooden dam is often carried out, since a decayed plank gives a chance for the ice to bite into the surface of the upper deck. With a few planks gone destruction follows at a cumulative



Section of dam for low head and soft bottom.

rate. In the case of reinforced concrete dams the deck rises by an easy incline from the very bed of the river, the surface is smooth, uniform and very hard. It lifts the whole mass of ice easily and smoothly to the crest of the dam and the easy incline of the apron drops it safely to the foot. If any direct expansive force of the ice exists it has no effect. The ice is merely lifted.

Seventh—*Time Required for Building.*—The time required for the construction of a dam is often a serious matter. Many a dam has been postponed for nearly a year because it would not be safe to construct it late in the season and risk severe injury by late fall floods. The record of one of these dams, 194 feet long and 10 feet high, build without machinery in twenty-two

ordinary working days, is a record which probably will never be again obtained except when using a similar method.

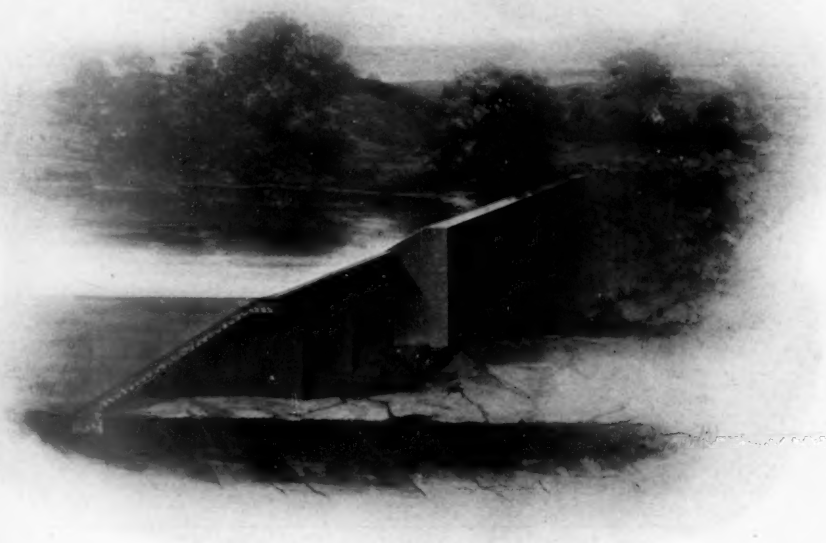
Eighth—*Stability.*—The crushing strength of massive masonry is a somewhat uncertain quantity and therefore low unit values are used for working stresses whenever crushing strength becomes a factor in the design. In the case of a reinforced concrete structure the stresses on every part of the

Section of concrete-steel dam with half-apron.

dam are very definite and the engineer can not only tell exactly how much stress will be found in each detail of the design of the dam, but he can also design the work with any desired factor of safety. In this respect the design of such a dam becomes a very definite problem—like the design of a bridge.

Ninth—*Closing the Dam.*—The problem of closing the dam is often a very serious one which taxes the ingenuity of the engineer to the utmost. The method adopted in the Schuyler-

ville Dam shows one of the peculiar characteristics of these dams. A water-way which would accommodate the ordinary flow of the river, was left so that the water flowed through the dam. This dam was begun September 27, 1904, and was finished December 31, 1904. For over two months the water was allowed to flow through the channels which were left. On March 11, 1905, the openings were closed up. The time required for closing was *forty-five minutes.* In any other form of

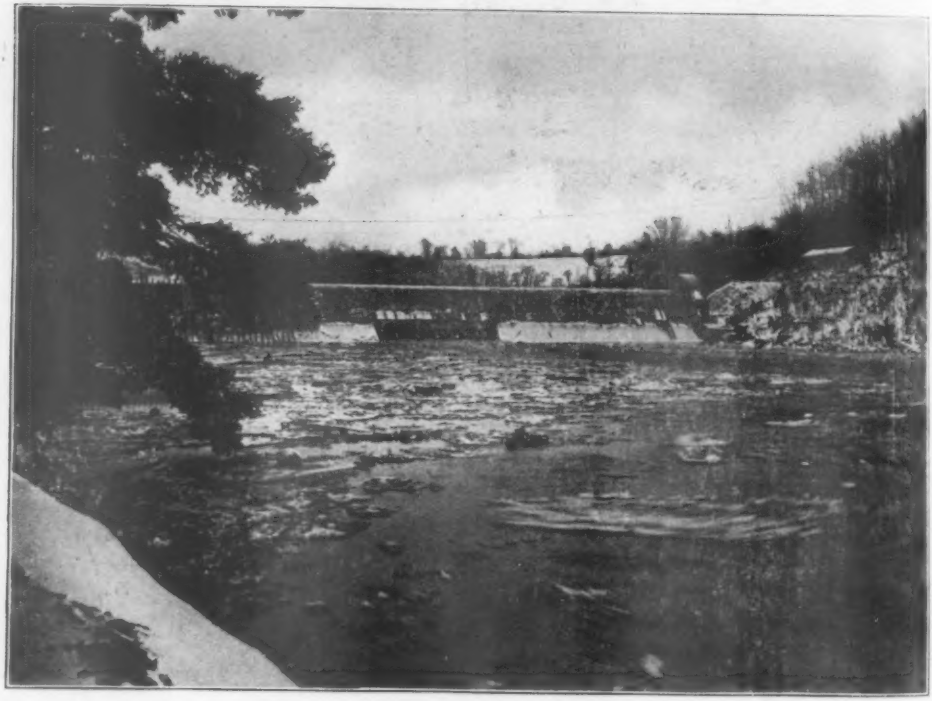


Section of concrete-steel dam—open front. For moderate head and ledge foundation.

dam used such a feat would not be even approximately possible.

Tenth.—The construction of these hollow dams has made it possible not only to avoid the usual expense of a gate house, which can be placed inside of the dam, but it will even permit the power-house to be located inside of the dam and thus effect a very considerable saving on what would otherwise be the combined cost of a dam, gate-house and power house. An il-

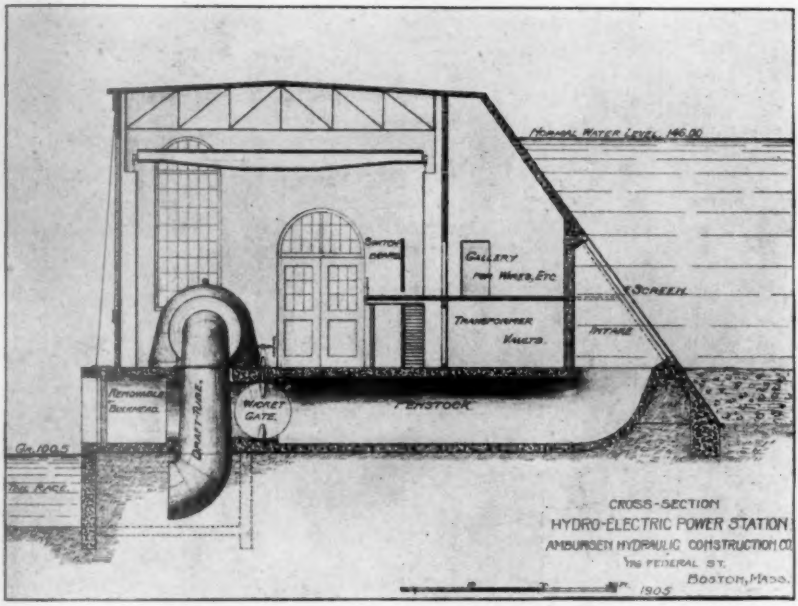
Schuylerville Dam. Under construction.



Schuylerville dam. Completed, except closing.

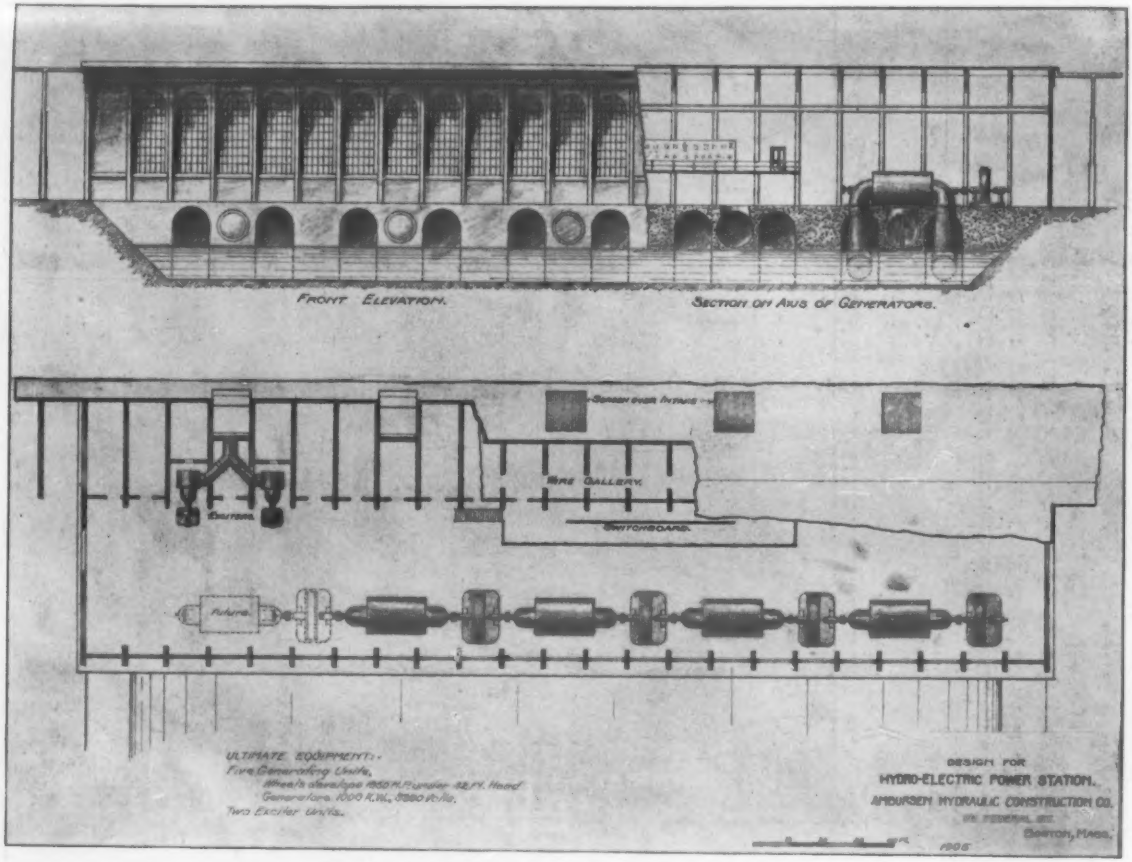
lustration of this is given in the design of the Oakdale power house at Tippecanoe, Ind.

Eleventh—*Cost.*—As intimated before, the cost is invariably cheaper than that of any other good dam. A timber dam *may* be constructed so flimsily that its cost will be lower than one of these dams, but as such a dam will ordinarily be washed out by the first unusual flood, there is no economy in it. In fact, it may be demonstrated that when you consider that the



Section of Oakdale power-house, Tippecanoe, Ind.

cost of a dam (like that of any other structure) is its total cost over a long series of years, and must include all maintenance charges, the real cost of a wooden dam is even greater than that of a reinforced concrete dam. It should be strongly emphasized that this method of building a strictly first-class and permanent masonry dam at a comparatively low cost has already rendered financially practicable the utilization of many water-power sites which otherwise could not be utilized except at an expense which would not be justified by the returns.



Elevation of Oakdale power-house, Tippecanoe, Ind.

MR. C. A. HEXAMER:—The interest I have in reinforced concrete buildings is purely from an insurance viewpoint. Fortunately, there has been no serious fire involving a reinforced concrete building full of inflammable material, and therefore no actual fire test of this class of construction. Hence the insurance engineer is at present withholding his verdict. There is, however, a committee of the National Fire Protection Association at work on the question of the fire-retardent quality of this class of construction. At the annual meeting of the National Fire Protection Association, in May last, a preliminary report was presented by the committee embodying the following fundamental principles of safeguarding reinforced concrete construction:

First.—The work should invariably be designed and its entire erection supervised personally by engineers of skill and experience in this particular line.

Second.—Concrete for fire proof construction should be composed of high-grade tested Portland cement, clean sand, and broken stone, gravel, slag or cinders(?), so proportioned that the cement will completely fill the voids in the sand and the mortar thus formed will a little more than fill the voids in the aggregate.

Third.—The materials should be well mixed by machine with enough water to make the mass distinctly a "wet mixture," and should be tamped down so that no voids are left.

Fourth.—All steel members of whatever style should be imbedded at least two inches in the concrete, and in the case of important load-carrying members, three inches.

Fifth.—No cement work of any kind should be laid in cold weather without being safely guarded against freezing. This may be disputed, but is correct beyond reasonable doubt.

MR. JAMES S. MERRITT said that on account of the lateness of the hour he would not attempt any discussion of the use of expanded metal for the Reinforcement of Concrete, but would refer to some instances in which reinforced concrete, carefully designed and properly mixed and put in place, had survived exceedingly severe treatment. Six or eight lantern slides showed concrete floors which had been cut through in the most reckless fashion to permit the passage of belts, pipes, spouts, etc.

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In one case a steel beam, which had been intended to support the expanded metal and concrete floor, and come in the way of a large grain spout and had been cut entirely through, after the completion of the building. Without any additional reinforcement the floor was supporting the two halves of the beam, the load being transferred to the adjoining beams, which were about 5′ away on either side.

HOLLOW CONCRETE BUILDING BLOCKS.

MR. E. P. COWELL:—That these blocks are becoming an important factor in building construction is admitted by all who have carefully investigated the subject. Concrete building blocks were practically unknown five years ago; since then 150 machines have been patented or are being made, and 1500 firms are making the blocks in this country.

The principal cause of the sudden development in this industry is the growing scarcity and consequent increase in price of lumber, and the high rates of wages forced by labor unions; also the low cost and improved quality of American cement; also the fact that concrete construction can be carried on in regions where lumber and clay are unavailable, with only cement, sand and water.

The blocks are made of a variety of sizes and shapes, and of materials and in proportions thereof innumerable, sometimes of one piece for a section of wall and again in two pieces (outside and inside).

Single blocks are made as large as 8 feet long and 8 inches wide and 10 inches thick, reinforced by steel rods. This tends towards concrete beam construction, though used as lintels. Blocks are rarely made longer that 6 feet without reinforcement. Single-piece hollow blocks are made 20 to 32 inches long by 8, 9 and 12 inches other dimensions, to make the full thickness of the wall. Two-piece blocks are made, as the name implies, for face and back wall. An argument in favor of the single-piece block is that when laid in place a section of the wall is completed, requiring no bonding to the front, containing 30 per cent. air space generally; more material and strength, therefore better and more economical than two-piece system. Advocates of two-piece system claim to secure a drier inside

wall, with less material, having 50 per cent. air space and present a more even inside wall upon which to plaster.

Following are a few of the proportions of materials used by different makers of blocks:

1 cement 4 sand.
1 " 4 " and gravel.
1 " 5 "
1 " 2 " 4 cinder.
1 " 1 " 2 crushed stone.
1 " 3 "
1 " 2 " sometimes used as facing of blocks,

with the view of rendering the blocks more impervious to moisture, but that seems unnecessary, as the concrete becomes practically waterproof when set, thoroughly crystallized. After the materials are mixed dry, water should be added from a sprinkling can till the mass is of a uniform color and sufficiently wet to retain shape when squeezed in the hand. The quantity of water required will vary with the condition of the sand and percentage of humidity in the atmosphere. Shovel the mixture into the mold in small quantities, meanwhile constantly tamping. Remove block on the platten to a place under cover, where it shall remain for at least one week (two weeks shows greater strength), sprinkle the block next morning and twice daily for one week, when the block may be safely used in building.

In a large city some distance from Philadelphia, one firm employing twenty-five men making hollow blocks supplied them to eighty-six dwellings and three large factories in three months this summer. These were generally sent out less than a week old, and rarely watered more than six times before placing in the yard exposed to the sun's action. No failures have so far accrued and demand exceeds production, showing that satisfaction has been given architects and builders. Other makers in the same city have furnished, in total, twice the above quantity, indicating popularity of Hollow Concrete Building Blocks. One peculiar feature of the business in that city is the uniform favor shown for blocks with an imitation rock face that is so palpable an imitation of stone work that it is repellant. A neat appearance is given by a plain or tooled face. The material we have to work with is so well adapted to many uses

and designs that it deserves a better fate than being considered an imitation of something else. Let it stand for what it is—the best of building materials.

The solid wall, or so-called Monolith style of Concrete Building Construction being an established fact, why should not the block business thrive? The blocks being made in smaller units are less liable to contain defects than a large mass.

The most beautiful architectural effects may be secured by using molds for solid or monolith work, and surely the same ingenuity may be developed with hollow blocks, though it must be admitted that up to the present time we are generally confronted with the nightmare of imitation cut stone.

Adaptability to any climate, residences built in our Northwestern cities, in Lower California, along both sea coasts and in the tropics, fulfill all the requirements of a perfect structure, entirely dry, cool in summer and warm in winter. Fire protection is perfect; the material being practically indestructible. And consider the cheapness and ease of construction: with one good mason and a fair quality of laboring men, an ordinary plain building may be erected of as durable a character as the most skilled and high-priced men could build, in many cases less than a brick structure would cost, and in some cases less than frame.

For information, I append hereto the rules and regulations covering the manufacture and use of Hollow Concrete Building Blocks

APPENDIX.

RULES AND REGULATIONS COVERING THE MANUFACTURE AND USE OF HOLLOW CONCRETE BUILDING BLOCKS IN THE CITY OF PHILADELPHIA.

1. Hollow concrete building blocks may be used for buildings six stories or less in weight, where said use is approved by the Bureau of Building Inspection, provided, however, that such blocks shall be composed of at least one (1) part of standard Portland cement, and not to exceed five (5) parts of clean, coarse, sharp sand or gravel, or a mixture of at least one part of Portland cement to five (5) parts of crushed rock or other suitable aggregate. Provided, further, that this section shall not permit the use of Hollow Blocks in party walls; said party walls must be built solid.

2. All material to be of such fineness as to pass a one-half inch ring and be free from dirt or foreign matter. The material composing such blocks shall be properly mixed and manipulated, and the hollow space in said

blocks shall not exceed the percentage given in the following table for different height walls, and in no case shall the walls or webs of the block be less in thickness than one-fourth of the height. The figures given in the table represent the percentage of such hollow space for different height walls:

Stories.	1st	2d	3d	4th	5th	6th
1 and 2.....	33	33				
3 and 4.....	25	33	33			
5 and 6.....	20	25	25	33	33	33

3. The thickness of walls for any building where hollow concrete blocks are used shall not be less than is required by law for brick walls.

4. Where the face only is of hollow concrete blocks and the backing is of brick, the facing of hollow concrete blocks must be strongly bonded to the brick either with headers projecting 4 inches into the brick work, every fourth course being a heading course, or with approved ties, no brick backing to be less than 8 inches. Where the walls are made entirely of hollow concrete blocks, but where said blocks have not the same width as the wall, every fifth course shall extend through the wall, forming a secure bond. All nails where blocks are used shall be laid up in Portand cement mortar.

5 All hollow concrete building blocks before being used in the construction of any buildings in the City of Philadelphia shall have attained the age of at least three (3) weeks.

6. Wherever girders or joists rest upon walls so that there is a concentrated load on the block of over two (2) tons, the blocks supporting the girder or joists must be made solid. Where such concentrated load shall exceed five (5) tons, the blocks for two (2) courses below, and for a distance extending at least eighteen inches each side of said girder shall be made solid. Where the load on the wall from the girder exceeds five (5) tons, the blocks for three (3) courses underneath it shall be made solid with similar material as in the blocks. Wherever walls are decreased in thickness the top course of the thicker wall to be made solid.

7. Provided always, that no wall or any part thereof composed of hollow concrete blocks shall be loaded to an excess of eight (8) tons per superficial foot of the area of such blocks, including the weight of the wall, and no bl cks shall be used that have an average crushing at less than 1,000 lbs. per sq. in, of area at the age of 28 days, no deduction to be made in figuring the area for the hollow spaces.

8. All piers and buttresses that support loads in excess of five (5) tons, shall be built of solid concrete blocks for such distance below as may be required by the Bureau of Building Inspection. Concrete lintels and sills shall be reinforced by iron or steel rods in a manner satisfactory to the Bureau of Building Inspection, and any lintels spanning over four feet six inches in the clear shall rest on solid concrete blocks.

Provided, that no hollow concrete building blocks shall be used in the construction of any building in the City of Philadelphia, unless the maker of said blocks has submitted his product to the full test required by the Bureau of Building Inspection, and placed on file with said Bureau of Building Inspection a certificate from a reliable testing laboratory, showing

that samples from the lot of blocks to be used have successfully passed the requirements of the Bureau of Building Inspection, and filing a full copy of the test with the Bureau.

10. A brand or mark of identification must be impressed in or otherwise permanently attached to each block for purpose of identification.

11. No certificate of approval shall be considered in force for more than four months, unless there be filed with the Bureau of Building Inspection, in the City of Philadelphia, at least once every four months following, a certificate from some reliable physical testing laboratory showing that the average of three (3) specimens tested for compression, and three (3) specimens tested for transverse strength comply with the requirements of the Bureau of Building Inspection of the City of Philadelphia, samples to be selected either by a building inspector or by the laboratory, from blocks actually going into construction work. Samples must not be furnished by the contractors or builders.

12. The manufacturer and user of any such hollow concrete blocks as are mentioned in this regulation, or either of them, shall at any and all times have made such tests of the cements used in making such blocks or such further tests of the completed blocks, or of each of these, at their own expense, and under the supervision of the Bureau of Building Inspection as the Chief of said Bureau shall require.

13. The cement used in making said blocks shall be Portland cement, and must be capable of passing the minimum requirements as set forth in the "Standard Specifications for Cement" by the American Society for Testing Materials.

14. Any and all blocks, samples of which on being tested under the direction of the Bureau of Building Inspection, fail to stand at twenty-eight days the tests required by this regulation, shall be marked condemned by the manufacturer or user and shall be destroyed.

15. No concrete blocks shall be used in the construction of any building within the City of Philadelphia until they shall have been inspected, and average samples of the lot tested, approved and accepted by the Chief of the Bureau of Building Inspection.

SPECIFICATIONS COVERING METHOD OF TESTING HOLLOW BLOCKS.

1. These regulations shall apply to all new materials, such as are used in building construction, in the same manner and for the same purposes, as stones, brick, concrete, are now authorized by the building laws, when said new material to be substituted departs from the general shape and dimensions of ordinary building brick and more particularly to that form of building material known as Hollow Concrete Block manufactured from cement and a certain addition of sand, crushed stone or similar material.

2. Before any such material is used in buildings, an application for its use and for a test of the same must be filed with the Chief of the Bureau of Building Inspection. A description of the material and a brief outline of its manufacture and proportions of the material used must be embodied in the application.

3. The material must be subject to the following tests: Transverse, Com-

pression, Absorption, Freezing and Fire. Additional tests may be called for when, in the judgment of the Chief of the Bureau of Building Inspection, the same may be necessary. All such tests must be made in some laboratory of recognized standing, under the supervision of the engineer of the Bureau of Building Inspection. The tests will be made at the expense of the applicant.

4. The results of the tests, whether satisfactory or not, must be placed in file in the Bureau of Building Inspection. They shall be open to inspection upon applicaion to the Chief of the Bureau, but need not necessarily be published.

5. For the purposes of the tests, at least twenty (20) samples or test pieces must be provided. Such samples must represent the ordinary commercial product. They may be selected from stock by the Chief of the Bureau of Building Inspection, or his representative, or may be made in his presence, at his discretion. The samples must be of the regular size and shape used in construction. In cases where the material is made and used in special shapes and forms too large for testing in the ordinary machines, smaller sized specimens shall be used as may be directed by the Chief of the Bureau of Building Inspection, to determine the physical characteristic specified in Section 3.

6. The samples may be tested as soon as desired by the applicant, but in no case later than sixty days after manufacture.

7. The weight per cubic foot of the material must be determined.

8. Tests shall be made in series of at least five, except that in the fire tests a series of two (four samples) are sufficient. Transverse tests shall be made on full-sized samples. Half samples may be used for the crushing, freezing and fire tests. The remaining samples are kept in reserve, in case unusual flaws, or exceptional or abnormal conditions make it necessary to discard certain of the tests. All samples must be marked for identification and comparison

9. The transverse test shall be made as follows: The samples shall be placed flatwise on two rounded knife edge bearings set parallel, seven inches apart. A load is then applied on top, midway between the supports, and transmitted through a similar rounded knife edge, until the sample is ruptured. The modulus of rupture shall then be determined by multiplying the total breaking load in pounds by twenty-one (three times the distance between supports in inches) and then dividing the result thus obtained by twice the product of the width in inches by the square of the depth in inches. $R=\frac{3\,W\,l}{2bd}$ No allowance should be made in figuring the modulus of rupture for the hollow spaces.

10. The compression test shall be made as follows: Samples must be cut from blocks so as to contain a full web section; samples must be carefully measured, then bedded flatwise in plaster of Paris to secure a nuiform bearing in the testing machine and crushed. The total breaking load is then divided by the area in compression in square inches. No deduction to be made for hollow spaces; the area will be considered as the product of the width by the length.

11. The absorption tests must be made as follows: The sample is first thoroughly dried to a constant weight. The weight must be carefully recorded. It is then placed in a pan or tray of water, face downward, immersing it to a depth of not more than one-half inch. It is again carefully weighed at the following periods: thirty minutes, four hours, and forty-eight hours, respectively, from the time of immersion, being replaced in the water in each case as soon as the weight is taken. Its compressive strength, while still wet, is then determined at the end of the forty-eight hour period in the manner specified in Section 10.

12. The freezing tests are made as follows: The sample is immersed, as described in Section 11, for at least four hours and then weighed. It is then placed in a freezing mixture or a refrigerator, or otherwise subjected to a temperature of less than 15 deg. F. for at least twelve hours. It is then removed and placed in water, where it must remain for at least one hour, the temperature of which is at least 150 deg. F. This operation is repeated ten times, after which the sample is again weighed while still wet from the last thawing. Its crushing strength should then be determined as called for in Section 10.

13. The fire test must be made as follows: Two samples are placed in a cold furnace in which the temperature is gradually raised to 1700 deg. F.; the test piece must be subjected to this temperature for at least thirty minutes. One of the samples is then plunged in cold water (about 50 deg. F. to 60 deg. F.) and the result noted. The second sample is permitted to cool gradually in air, and the results noted.

14. The following requirements must be met to secure an acceptance of the materials: The modulus of rupture for concrete blocks at twenty-eight days old must average one hundred and fifty and must not fall below one hundred in any case. The ultimate compressive strength at twenty-eight days must average one thousand pounds per square inch, and must not fall below seven hundred in any case. The percentage of absorption (being the weight of water absorbed divided by the weight of the dry sample), must not average higher than 15 per cent. and must not exceed 20 per cent. in any case. The reduction of compressive strength must not be more than thirty-three and one-third per cent., except that when the lower figure is still above one thousand pounds per square inch, the loss in strength may be neglected. The freezing and thawing process must not cause a loss in weight greater than ten per cent., nor a loss in strength of more than 33⅓ per cent., except that when the lower figure is still above one thousand pounds per square inch, the loss in strength may be neglected. The fire test must not cause the material to disintegrate.

15. The approval of any material is given only under the following conditions:

(a) A brand mark for identification must be impressed on or otherwise attached to the material.

(b) A plant for the production of the material must be in full operation when the official tests are made.

(c) The name of the firm or corporation and the responsible officers must be placed on file with the Chief of the Bureau of

Building Inspection, and changes in the same promptly reported.

(d) The Chief of the Bureau of Building Inspection may require full tests to be repeated on samples selected from the open market, when, in his opinion, there is any doubt as to whether the product is up to the standard of these regulations, and the manufacturer must submit to the Bureau of Building Inspection once in at least every four months a certificate of tests showing that the average resistance of three specimens to cross breaking and crushing are not below the requirements of these regulations. Such tests must be made by some laboratory of recognized standing on samples selected by a building inspector or the laboratory, from material actually going into the construction, and not on ones furnished by the manufacturer.

(e) In case the results of tests made under these conditions should show that the standard of these regulations is not maintained, the approval of this bureau to the manufacturer of said blocks will at once be suspended or revoked.

Tests made under the requirements of the City of Philadelphia on concrete blocks in the market here have developed about the following results·

Modulus of rupture, 150 to 175 pounds.

Compressive strength, 1200 to 1600 pounds per square inch.

Absorption, 5 per cent.

The compressive strength is reduced little, if any, by the water absorbed.

Freezing tests show little loss.

The average compressive strength after freezing is in the vicinity of 1000 pounds per square inch.

The blocks passed the fire tests well.

A 10,000 HORSE-POWER STEAM TURBINE.

The two steam turbine sets of 10,000 horse-power each, which are being installed at the Rhenanian Westphalian Electricity Works, are the largest turbine sets, and in fact the largest stationary engines of all Europe. Each of these gigantic engines comprises a turbine running at 1,000 r. p. m., which is direct-connected to a rotary current generator of 5,000 kilowatts, 5,000 volts, and 50 periods per second, as well as to a direct-current generator of 1,500 kilowatts and 600 volts, and to a central condensing plant. The whole set is 20 meters in length, and weighs 190 tons, of which 9.4 meters and 107 tons correspond to the turbine. The maximum height of the turbine above the floor is 2.6 meters. The turbine is of the single-cylinder type, and has only two bearings, one of which serves at the same time as a bearing to the alternator. The governor is made to compensate to 1 per cent. of any oscillations in the angular speed, with variations in the load as high as 20 per cent., while the maximum variation in the number of revolutions between running at no load and at full load is not to exceed 5 per cent. Another unit of the same size is shortly to be installed at the power station in a Westphalian mining company.—*Scientific American.*

TEN YEARS OF ELECTRIC REDUCTION AT NIAGARA FALLS.

The present month brings the tenth anniversary of the establishment of electro-chemical industries at Niagara Falls. On the developments of the decade the *Electro-Chemical and Metallurgical Industry* comments as follows:

On August 26, 1895, the Niagara Falls works of the Pittsburgh Reduction Company started operation. On October 19 of the same year the current was turned on at the plant of the Carborundum Company. Thus, it is now just ten years that electro-chemical activity started at Niagara, and in this short space of time more than a dozen varied electro-chemical industries have grown up and are flourishing within a radius of two miles from the falls. In electric furnaces are made at Niagara artificial graphite, siloxicon, silicon, carborundum, alundum, calcium carbide, phosphorus and various ferro-alloys. By electrolysis of fused electrolytes are made aluminum, sodium (for the production of various important derivatives), and caustic soda and chlorine. The latter two products are also made by electrolysis of aqueous solutions; while other products of such processes are caustic potash and hydrochloric acid and chlorates. The only example of a process using electric discharge through gases on a commercial scale at Niagara is the production of ozone for the manufacture of vanillin.

As the latest developments we may mention that ground has recently been broken for the caustic soda and chlorine works, which will use the Townsend diaphragm cell, while in the old barn in which Mr. Rossi made his pioneer experiments on ferro-titanium Mr. Rothenburg's process of agglomerating in the electric furnace magnetic iron concentrates now undergoes an experimental trial. This is certainly a splendid development, and while as a necessary concomitant to the success achieved there have been commercial failures, yet their number is remarkably small. The most notable one is probably that of the Atmospheric Products Company, on the success of which very great hopes had been founded. In the interest of the problem it it greatly to be regretted that no exact information on the causes of the failure has been published. Certainly the problem itself cannot be considered to be dead forever.

THE HEAVIEST RAILS.

The rails on the Belt Line Road around Philadelphia are the heaviest rails used on any railroad in the world. They weigh 142 pounds to the yard, and are 17 pounds heavier than any rails ever used before. They are ballasted in concrete, and 9-inch girders were used to bind them. All the curves and spurs were made of the same heavy rails, and the tracks are considered superior to any railroad section ever undertaken. The rails were made especially for the Pennsylvania Railroad by the Pennsylvania Steel Company. An officer of the railroad company states that this section of roadbed will last for twenty-five years without repairs.—*International Railway Journal.*

CHEMICAL SECTION.

(*Continued from Vol clx, p. 368.*)

*Mica and the Mica Industry.

By George Wetmore Colles.†

[In the concluding section of his exhaustive paper, the author deals with the statistics of the mica industry.—The Editor.]

VII. STATISTICS.

The statistics here given have been worked up from three principal sources; namely, the charts and some pamphlets on the subject, issued by the United States Geological Survey; the annual volumes of the "Mineral Industry," published by the Editorial Staff of the "Engineering and Mining Journal;" and the statistics on imports published by the Bureau of Statistics of the United States Government.

Concerning these authorities a word here may not be out of place. With regard to the figures of the United States Geological Survey, it may be said of them, in the words of Mr. Rothwell, late editor of the "Mineral Industry," that they are "frequently but little short of absurd;" or rather it should be said, that they are in many cases *wholly* absurd, and the phrase

*Read by title. †Copyright, 1905, by George Wetmore Colles.

"little *short* of absurd" may be apropriately reserved for some of Mr. Rothwell's own figures.*

However, as between the two I prefer to rely on those of the "Mineral Industry," and in justice to that invaluable publication it must be said that outside of foreign sources (for which the editors can hardly be held responsible) the discrepancies are few and the figures in general accord with known facts. The government figures are on the contrary open to such great objections that they are not to be accepted without much reserve. I have, therefore, on the accompanying charts unhesitatingly followed the former authority.

The statistics of imported merchandise published by the Department of Commerce and Labor should, it would seem, be

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*As instances of the former, I may cite the value of asbestos, which is given by the Geological Survey as about $17.00 per ton, whereas it has been computed by a competent authority that the actual cost of mining alone amounts to about $55.75 per ton; or again, where the value of the rather common mineral *rutile* is given as $5.00 per *pound*, when the retail price quoted in the catalogue of a large New York dealer is thirty cents, and the average valuation of imports is about eleven cents per pound. As an instance of the latter, may be cited Mr. Rothwell's values for sheet mica produced in "other States," which include small amounts mined in western States, such as Idaho, Nevada and Wyoming. These he puts at an average of $2.25 per pound for 1896-7, or two and a-half times the value of North Carolina mica, while in 1898-9 it had suddenly dropped to $1.00, which is still in excess of the latter. These are for mica at the point of production, and in view of the known inferiority and lower market prices of the western mica, added to the large excess in transportation rate to the nearest market, it would seem certain that the correct value would be considerably less, instead of more, than that given for North Carolina mica. Again, the total value of imports into the United States for 1892 are given as $100,846, while upon the next page those from Canada alone are valued at $150,053, in spite of a large importation of Indian mica; and although the United States value is for the fiscal year, yet the value given for the succeeding year, 1893, is only $120,864, so cannot be said to lend an explanation.

The statistics reported for India are in no better condition, for the total exports are found to exceed the production, notwithstanding that a certain portion of the latter must be used in native industries, and notwithsanding this, the values of the exports are quoted at something like ten times the values of the product up to 1898, when the production value suddenly jumps to a figure approximately equal to the export figure. In the statistics here given both the export quantities and values have been taken as the correct ones and at all events those which concern us much more than the actual quantities and values produced.

exact as far as they go, at least they pretend to be, and there is no reason why they should not be so. Unfortunately the imports for mica have been classified only since the year 1894. These statistics are given for fiscal years ending June 30, and for purposes of proper comparison they have been reduced to calendar years in the charts by taking for any calendar year one-half the value given for the fiscal year ending on June 30 of the calendar year, and one-half of the amount for the year following.*

In like manner the statistics on Indian exports, which are taken as equal and which for our purposes are practically equivalent to the total Indian production, are given for fiscal years ending March 31, and the chart-points are figures for calendar years, found by taking one-quarter of the amount given for the fiscal year and three-quarters of that for the following year.

In addition to these sources, some fragmentary but, so far as they go, valuable figures relating to the Canadian industry are given by J. Obalski, Mining Engineer for the Quebec gov-

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*It will of course be understood that by this method the exact amount imported during any calendar year is not found, and frequently there is a very wide variation between the amount so found and the actual amount; but this is of no real consequence in the chart, and in fact there is a reason why the average so found is better for our purposes than the true amount. The chart line or "curve" so found will be smoother and freer from jagged variations and thus show more clearly the trend through a series of years. Consider, moreover, that as a matter of fact the amount imported in any year does not agree with the amount exported from other countries, not only because of the time of transport, but also because a large fraction of the total imports is re-exported from England after lying for an indefinite period; nor does it agree with the amount of imported mica actually used, that is, entered for consumption for that year, because imported material lies stored an indefinite time after import in the Customs warehouses. These considerations will help show the futility of supposing that there can be anything like exact statistics in this industry.

†None the less it is very regretable that the native mica consumption of India cannot be given nor tabulated. What it amounts to is a mystery. By one authority it is given as several times as large as the exports; by another as about equal; while the Government statistics are so utterly discordant that nothing can be learned from them. No doubt exists, however, that India's 225,000,000 inhabitants consume an astonishing quantity of mica.

ernment, in his extended report on "Mica," 1901, which have been used as far as possible.*

The values in the accompanying charts are in all cases, except for India (those at the point of production, so that the same article will be of *less* value in proportion to the distance of the point of production from the market, and conversely, articles which appear of *equal* value on the chart would really be of superior quality in the case of the most distant point of production. With these remarks I think the diagrams will be self-explanatory.

It will be seen that the statistics at hand are not to be taken too seriously or punctiliously, but in a merely general fashion. There is unquestionably great difficulty in collecting mica statistics, more so than in the case of other minerals, owing to the reticence of the mine owners, and their reluctance to tell anything whatever with relation to their business. It is believed that in many cases the information reported is purposely falsified. It is regrettable also that the figures extend back only for ten to twenty years, and cannot be fully brought down to date owing to the delay in reporting statistics. Nevertheless I believe that such statistics as are here given will prove vastly better than none at all, as indicative of the present actual state of the mica industry and its probable future.

In all the charts, both the *quantities* and *values* are given as far as possible, both being mapped upon the same chart, and to distinguish them the quantities are drawn in light, the values in heavy lines. While both are determinative to some extent, and important as means for forming a judgment, the *values* will generally be found the most accurate guide to the state of the industry in each case.

The Canadian product as tabulated in the charts includes *all* of the product of Canada, of which trifling amounts consist of

*Here also it is to be noted that several departments of the Dominion government keep independent statistics of the mica production, and taken together they form a beautiful charivari of discord. To find the true values from this medley is a puzzle which would indeed tax the abilities of the proverbial "Philadelphia lawyer." The figures are dependent on the exertions of two provincial governments as well as of the Dominion government. The statistical branch of the Ontario government is evidently not all that it should be, even if the others are.

white mica, insufficient, however, to alter sensibly the general proposition that Canadian mica and amber mica are equivalent terms.

The statistics of the United States imports, as well as foreign reports, show that a great number of other countries from all the continents figure as mica producers in a small and sporadic way, but all these countries put together form in proportion a total too insignificant to be perceptible on the scale of the charts. The only three countries which have ever been steady producers for any length of time are *Germany*, whose lepidolite deposits on the Bohemian border are mined for lithia in small amounts annually;* *Australia* (South and West), which produced about $29,000 worth between 1891 and 1900, since which time production has ceased; and *Russia*, which produced about $14,000 worth between 1891 and 1898, since which time none is reported. It is perhaps worth remarking that even Great Britain produced about six tons in 1897, valued at $8,635.

Although several countries of Europe have furnished and continue to furnish exported mica in trifling quantities to the United States, this can hardly be called native mica and is presumed to be imported mica manufactured in those countries before reshipment.

World's Production of Mica. Fig. 26.

In this chart the whole mica output of the world is shown as a total, and also distributed according to the three mica producing countries. As a natural result of thus lumping together the several nearly independent branches of the industry, there is discordance between the value and quantity curves. Besides the production of sheet mica, the great quantities of scrap for the ground mica industry, and the small quantity of lepidolite mined for lithia ore are included ton for ton. As a general indication of the status of the industry, the chart will be useful,

*The mica statistics in the German reports are consolidated with quartz and uranium ore so that it is impossible to separate them, but the whole amount is inconsiderable, embodying some sheet mica and some massive lepidolite.

referring, however, to the values only. The value lines show a slow decrease in the total mica produced from 1890 to 1894, and from 1894 a rapid increase up to 1902, amounting to a boom, the annual production rising from less than $300,000 to $800,000; that is to say, more than doubling. This boom

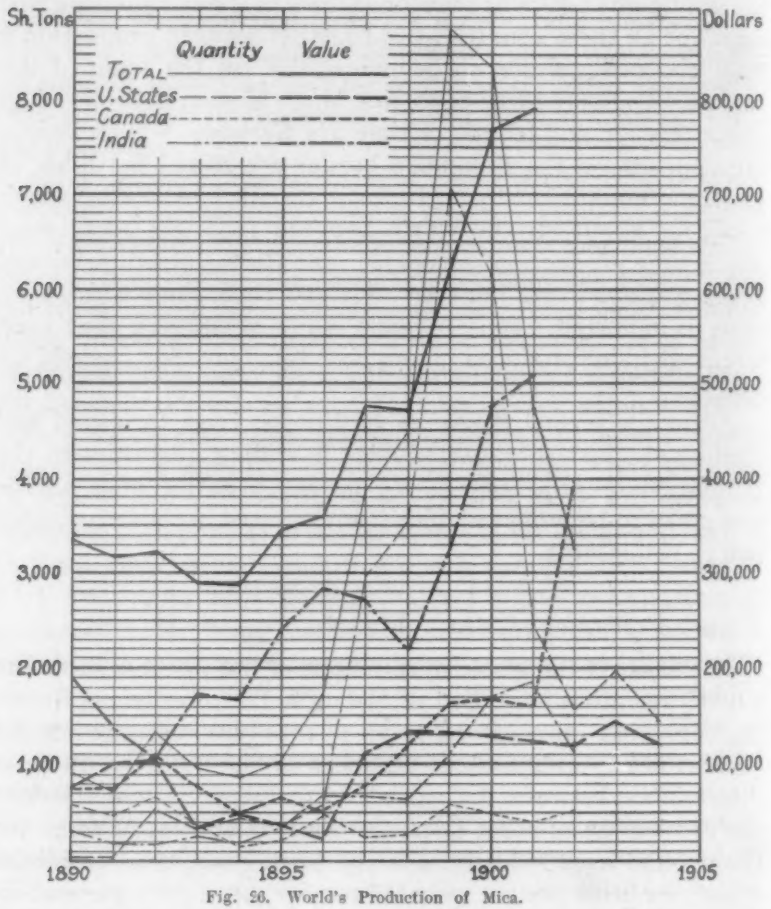


Fig. 26. World's Production of Mica.

was contemporaneous not only with the trade revival in the United States (the largest mica-consuming country), but more particularly with the great era of growth in the electrical industry, and also with the rise of the ground-mica industry to a place in the staple market. It was, however, the former and

not the latter cause which was the really important factor, as will be seen by consulting the several subordinate value-lines. The United States shows a generally declining state of the industry until 1896, and from that point to a sudden rise, which took the mica industry back to its status prior to 1888 (not shown in this chart) which lasted, however, but two years, and since then has barely held its own, with a declining tendency. The increase from 1896 to 1898 was due to sheet mica principally; but less to the aforesaid ground-mica industry, which took its great rise about this time, and it will be well seen how little effect it had on the continuous increase of the line of total values.

The Canadian value line shows likewise a declining state of the industry up to 1896, when it also began to increase at a rapid rate, which increase has been maintained ever since, but unlike that of the United States, it was not due to the short-lived "boom" of a new product,—in fact the ground-mica industry in Canada came to its end just at this time; but it was due solely to the rise of the electrical industries and the increasing appreciation of the value of Canadian mica for that purpose.

The Indian value curve on this chart shows a nearly steady increase since 1892, since which time it has quintupled in amount.

The great fact, however, indicated by this chart is the comparative proportions of the mica industries of the different countries. It is to be regretted that the figures only go back to 1890. If it were possible to carry them back, we should find a time less than ten years previous when the positions of the several countries would be actually the reverse of what we find them at present. In 1892 the United States industry had declined, and the other two had increased, until they were on a par with each other, each producing one-third of the world's total supply of mica, and though the great rise of the Indian industry dates from that year, the United States and Canadian industries declined still further, keeping nearly side by side with each other, but with Canada slightly in the lead, until 1896, since which time Canada has far outstripped the United States, and bids fair to rise to a parity with India, notwithstanding the rapid increase of the latter.

The quantity-lines of this table show nothing except the impropriety of adding together scrap and sheet mica. During the years 1869 to 1902, the total curve is dominated by that of the United States, whose 7,000 tons maximum is nearly all scrap, worth a fraction of a cent a pound. Whatever is valuable in these quantity-curves can best be elucidated from an examination of the subsequent charts for sheet and scrap mica respectively.

World's Production of Sheet Mica. Fig. 27.

The statistical data at hand have enabled these figures to be stated for the United States as far back as 1880, while those for Canada run back to 1886, and those for India back to 1889. Canada produced little or no mica before 1885, but India has produced and exported mica to Europe certainly for more than a century,* and has exported to the United States since 1883. The line of total values is not very different in character from that of Figure 26, but the addition of the year 1889 is very significant, as carrying it back to a new low point in the past. It will be seen that since 1889 the sheet-mica industry has multiplied itself more than six times.

The line of total quantities in this figure is chiefly interesting as showing more violent fluctuations than that of total values. In particular it is to be noted that, while there was an advance in the total value in 1902 over the previous year, there was a considerable falling off in the total quantity.

The United States value line is probably the most interesting feature of this chart, indicating as it does a condition of prosperity in the early eighties far in excess of anything the industry has enjoyed since. It was due, however, as will be seen from the quantity line, not to a greater quantity of mica mined,

*Fritz Cirkel, in a memoir recently published by the Mines Branch of the Canadian Government, states that the first exports from Bengal were in 1863. This is doubtless taken from British Customs Reports and indicates the first year in which exports of mica were of sufficient commercial importance to receive separate classification. Mica was sent to China from the Indian mines centuries ago, and the name "muscovy glass" indicates a similar importation into Western Europe through Russia rather than a hypothetical native Russian mica industry.

but to the high price obtained for it in the early days. During the years 1893 to 1896 the industry of mica mining was all but extinguished in the United States, and had dwindled to insignificant proportions compared with those of Canada and India.

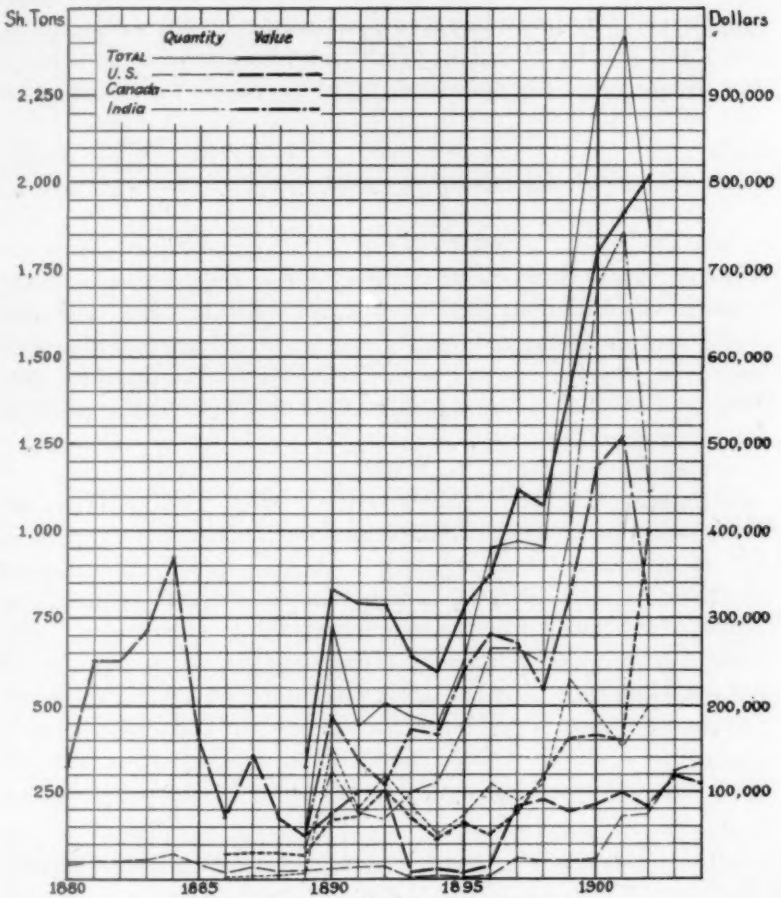


Fig.27, World's Production of Sheet Mica.

Since 1896, however, the industry shows sure signs of a permanent revival, for while the total value of the product has fully held its own, in the face of falling prices, the volume has continuously increased.

The Canadian and Indian value lines show substantially the

same features as were remarked in considering the previous chart, and both show a marked contrast to that of the United States. The Canadian line is one especially indicative of a young industry, and one having a great future before it. The Canadian and Indian quantity lines show a tendency to separate to a constantly greater extent, indicating an increasing value per pound of the Canadian product, and a diminishing value of the Indian, as will be seen later on in connection with the price-charts.

United States' Production of Sheet Mica. Fig. 28.

On this chart we examine on a more magnified scale the United States sheet mica industry from 1890 to the present time, to show its distribution by states. Up to 1893, and since 1900, no figures regarding the sources of domestic mica were kept. It was only during that period that this important data has been tabulated by Mr. Rothwell and his collaborators in his "Mineral Industry."* We know, however, that New Hampshire was prior to 1869 practically almost the sole source of supply in this country, after which time the lead was taken from it, and has been retained ever since by North Carolina. It is true that, at the beginnings of these chart lines in 1893, the North Carolina industry apparently finds itself approaching extinction. This was, however, doubtless only temporary, as the high value of the total between 1890 and 1893 was undoubtedly due to North Carolina and not New Hampshire mica. In 1896 North Carolina again experienced a boom, which reached its climax in 1898, and collapsed as rapidly as it rose. It is to be observed

*It may be thought surprising that so little information of any value regarding the immense mineral production of our country has been obtained from the departments of our government, whereas every other civilized government keeps such statistics. Such is the fact, however, and the figures that are put forward by the Geological Survey deserve but little reliance. This is partly, no doubt, because the statistical force is inadequate, its organization is inadequate, its means of support are inadequate, and the means at its command for collecting information is inadequate; at all events its secrecy is probably not trusted by those making reports. I reserve the right to suspect also that its brains are inadequate.

that the rise is much greater in the value lines than in the quantity lines, indicating a boom in price rather than a boom in actual mining. It may be added (what is not shown on the chart) that the New Hampshire industry has since then sunk into a condition aproaching extinction.

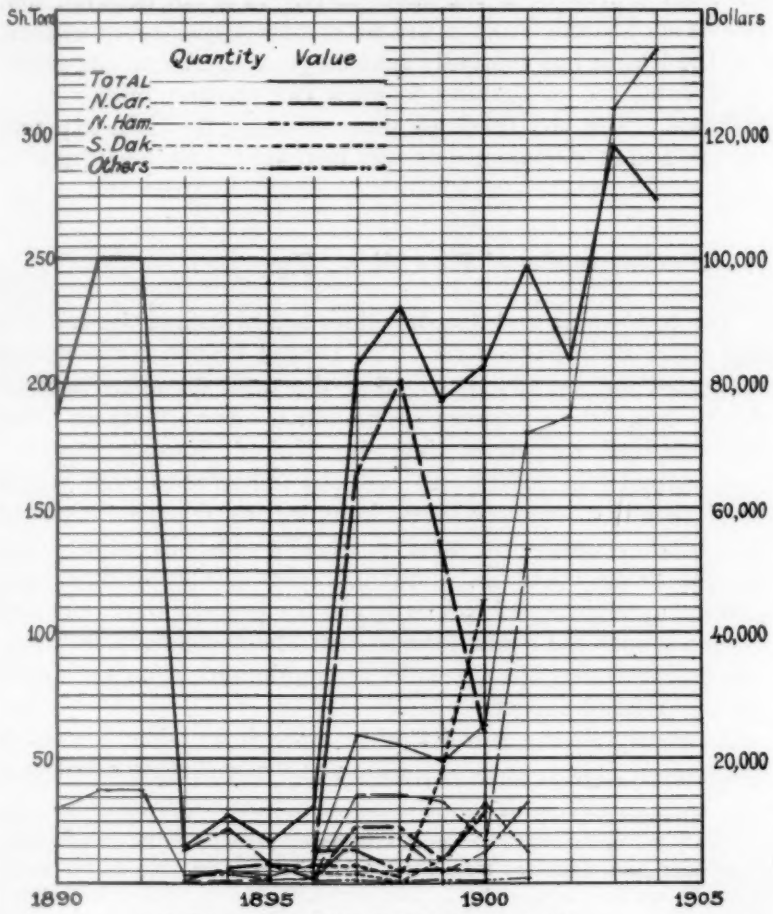


Fig. 28. United States Production of Sheet Mica.

Mica from other states first shows on the chart in 1896, in which year small quantities were produced in South Dakota, Nevada and Idaho, principally from the first. The Idaho industry has continued active in a small way up to the present

time, and may perhaps grow as a source of supply for the Pacific coast. The South Dakota industry has experienced a great boom, and in 1900 took a place apaprently ahead of that of North Carolina. This is a most surprising state of affairs, considering that every physical advantage and the quality of the mica is in favor of the latter state. It is not believed that the state of South Dakota will permanently maintain this lead, but the lead it has evidently reflects great credit on the enterprise exhibited in pushing forward the product into western markets. The fact tends to show strongly the influence that energy and modern methods may have on the success of an industry.

World's Consumption of Sheet Mica. Fig. 29.

The total value and quantity lines are of course the same in this chart as in Figure 26. The United States' consumption is figured out by adding together the total domestic production* and the imports. The lines for "Others' are then derived by subtracting the United States' consumption from the total.† It will be observed from these lines that this country uses from 55 to 60 per cent. of the total quantity of mica produced, that is, more than all the other countries combined, and this ratio has been practically maintained from 1890 to the present time. It corresponds with the great development of our electrical industry, but indicates perhaps a greater preponderance than we should have a right to expect.

As nearly all the world's mica, aside from what is used in the United States, goes to London as a distributing point, it is

*Only minute quantities of mica (averaging perhaps $1,000 in value per year) have been exported from the United States, a quantity which would be quite invisible on the chart. The condition of this mica is not stated, but it is believed to consist almost entirely of ground mica, thus still further reducing the actual quantity.

†The figures for United States consumption thus obtained for 1892 is slightly greater than the total production reported for that year making the "Others" line a negative quantity. Of course the fact is that the amount of mica carried in stock is not taken into account in this chart, which accounts for such individual discrepancies.

hard to say precisely how the product is to be divided between the different European countries. The following summaries of shipments from India to the different countries for the six

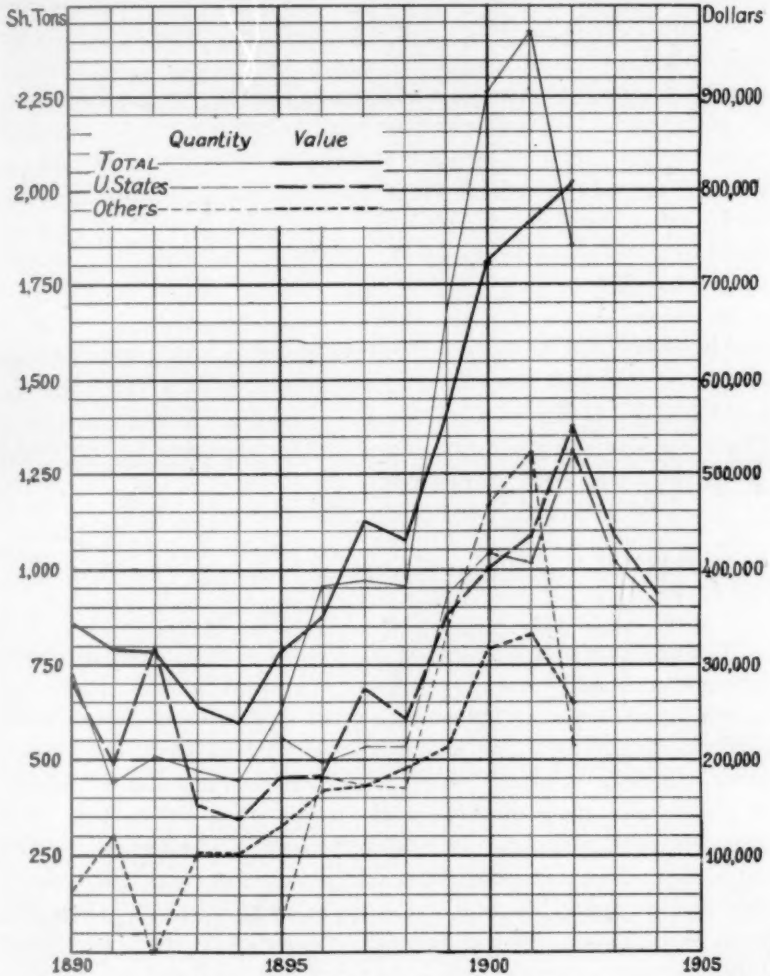


Fig. 29. World's Consumption of Sheet Mica.

fiscal years, 1891 to 1897, indicates in a general way the distribution: United States, 808 tons, 38½ per cent.; Great Britain, 1215 tons, 58 per cent.; Germany, 52 tons, 2½ per cent.; all others, 19 tons, 1 per cent.; total, 2094 tons.

Of the quantity shipped to Great Britain, nearly one-half was re-shipped to the United States. Of the balance, doubtless a considerable quantity went to Germany and France, small proportions being used by such manufacturing countries as Belgium, Australia, Italy and Switzerland. Needless to say, only manufacturing countries use mica in any considerable quantity, which means practically the United States, England, Canada, and a half-dozen European countries. The amount used by Canada is very small, and the exact amount cannot be learned. Up to within the last few years substantially all Canadian mica came to the United States, but now a large proportion of it goes to London, which is the great European mart for mica.

In recent years also the government statistics show large and increasing mica imports from Germany. As it is not to be supposed that this mica is produced there, it may safely be assumed that it is merely Indian mica floated in German bottoms. Sixty-six and forty-nine tons were thus imported in the fiscal years 1893 and 1894 respectively.

United States' Consumption of Sheet Mica. Fig. 30.

In this chart are shown the amounts of mica from the different countries which are used in the United States. Here the quantity lines are perhaps of equal if not greater significance than the value lines, on account of the great variation in the price of mica. United States mica has been constantly falling in price, whereas Canadian and Indian mica have been held more nearly constant. The quantity line in the United States from 1880 until 1900 has been fairly constant, with the exception of the period of depression from 1893 to 1896, when the mica industry was all but defunct. Since 1900 there has been a remarkable growth, which has not yet realized its climax. We must place one or perhaps several question marks after the United States figures, owing to the great difficulty in obtaining information as aforesaid.

Although 1883 is given as the first year when mica was imported from India, there were importations of mica reported

long previous to that time,* and this was in all probability India mica shipped to England and re-exported from there to the United States. It has been so considered in the chart. The imports of India mica beginning with 1883 grew rapidly

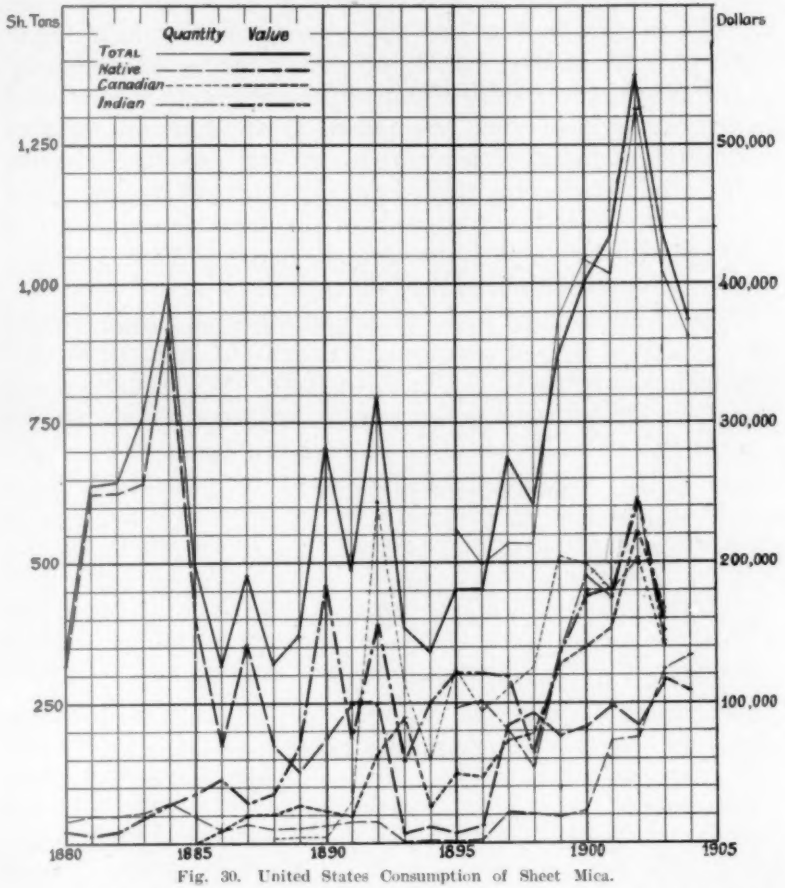


Fig. 30. United States Consumption of Sheet Mica.

up to about 100,000 tons annually from 1890 to 1898, during which time they were fairly constant around this figure, but since then the imports have practically doubled in volume and

*The year mica imports are first reported in the United States is 1869, and the quantity imported from then up to 1880 amount to about $40,000, or about $3500 a year.

value, and still outweigh the total of the United States production. Canada mica in the United States has experienced the same course of events, in fact the entire Canadian mica industry has, until recently, depended on the United States for a market. Beginning in 1886 imports of Canadian mica grew rapidly to nearly $100,000, an approximate equality with those of India, in 1893, but fell off during the period of depression from 1894 to 1896. From 1897 they experienced a rapid increase, and have since maintained an approximate equality with those of India. Both were for several years far in excess of the production of the United States, which in 1893 amounted to but little over five per cent. of the total consumption of mica; but the latest statistics show the native product has risen nearly to a position of equality with them.

It is of importance to inquire how the total production of sheet mica is divided according to uses. It is naturally impossible to obtain statistics of this nature. We may, however, put down the entire Canadian output, 500 tons in 1902, and an equal quantity of Indian mica, to electrical uses. We are safe in saying that at least one-half, perhaps three-fifths, of the total world's production is devoted to this purpose. Of the balance probably four-fifths, or 30 to 40 per cent. of the whole (including nearly all the United States and some Indian mica) is used for glazing in some form, the remaining ten per cent. being employed for special uses. While no accuracy is claimed for this allotment, it will serve its purpose well enough as a rough estimate.

(*To be concluded.*)

PROPER SITE FOR A WIND MILL.

The safest and most secure situation for a wind mill to avoid danger of being blown over has been generally supposed to be a place sheltered by trees or barns. Such, however, is not the case. The safest place for such a tower is on a hill, where the wind can strike it equally from all directions. In such a location shifting winds are less pronounced than behind buildings or hills, and it is also found that there is less lifting force to the wind in the open than behind structures.

THE FRANKLIN INSTITUTE.

(Stated Meeting, held Wednesday, October 18, 1905.)

Etching by Machinery.

By Louis Edward Levy.

Photo Chemist, Member of the Institute.

[Presentation of an Etch Powdering Machine, a newly invented device for applying resinous powder to metal plates in preparation for etching. The machine is designed to supplement the Levy Acid Blast in the process of etching by machinery. A number of plates powdered for various stages of the process were exhibited. The description of the apparatus is preceded by a consideration of the subject matter in general.—The Editor.]

It is only sixty-five years since the discovery of the Daguerreotype process of photography suddenly widened out the narrow confines of the Graphic Arts into a new and larger field. And it is only about fifty years since this field was expanded by combination with the lithographic processes; scarcely more than thirty years since it was extended into the region of the typographic arts by combination with the etching process and but little over twenty years since this, in turn, has been further enlarged into a practically boundless domain by the autoglyphic, or so-called half-tone process of photo-engraving.

When the illustrative value of the half-tone process, as shown by Ives in the early eighties, and its practical possibilities as indicated by the Meissenbach method of the same period, had been realized by my invention of the engraved line screen in 1887 and its practical perfection by my brother, Max Levy, in 1891, the way was opened for the general use of half-tone as well as line etchings in the illustration of daily newspapers. It was not long before commercial competition, along with the exigencies of modern journalism, led to various efforts to expedite the etching process, generally through the use of stronger mordants, and though something was gained in this direction, frequently at the expense of the workman's health, there still remained a further need of greater brevity in the process and the inevitable demand for greater brevity in the

cost. These requirements were sought to be met by my invention of the Acid Blast method of etching, which I had the honor of bringing out before this Institute in February, 1899. Much time and effort had, however, yet to be devoted to the perfection of the machine for the application of this process. The main obstacle that presented itself from the beginning was the necessity of making the apparatus proof against the nitric acid carried by the air blast, and the structural difficulty of working a thoroughly acid-proof material into the requisite form with an adequate degree of accuracy. The machines first put into practical use were made entirely of aluminum, that metal affording sufficient resistance to the action of nitric acid to make it practically proof against the dilute solutions used with the blast. In time, however, it was found that while parts of the machine which were subjected most to the acid blast, but which were intermittently washed by the water spray, such as the cover and plate-carrier, remained intact, the aspirators and other interior features of the machine were strongly affected by the resultants of the process of etching zinc. It developed that the aluminum gave way through the formation of its hydroxide, the trihydrate $Al_2(HO)_6$, doubtless due to the presence of free hydrogen in the course of the decomposition of the zinc by the acid. The use of vulcanized india rubber was also found objectionable, as that material is apt to become brittle from the effects of the nitric acid, and the atomizers to become gradually enlarged by the abrasion of the acid blast, thus changing the character of the spray. Eventually the entire apparatus, except the cover, carrier-plate and outer mechanism, has been made of a vitrified material which is permanently unaffected by the acid, or its products. In this form the machine has gone into extensive use and the blast method of etching, through its economic and sanitary advantages, has become firmly established in practice.

In the course of early experience with the acid blast it became apparent that the "powdering" of the plate, a preliminary operation of the etching process, could also be advantageously effected by means of a mechanism adapted for the purpose. This powdering process consists, at the outstart of the work, in a hardening of the soft ink composing the features of the design, so that the metal surface under the ink be thoroughly

protected from the action of the acid while the rest of the surface is being etched by it. This is effected by covering the plate with a resinous powder, some of which adheres to the viscid body of the ink when the surplus is brushed away. The plate so "topped" is then heated to the point where the resin melts into combination with the ink, making, when cold, an effective resistant to the acid. This operation is comparatively simple, requiring only a reasonable degree of care in

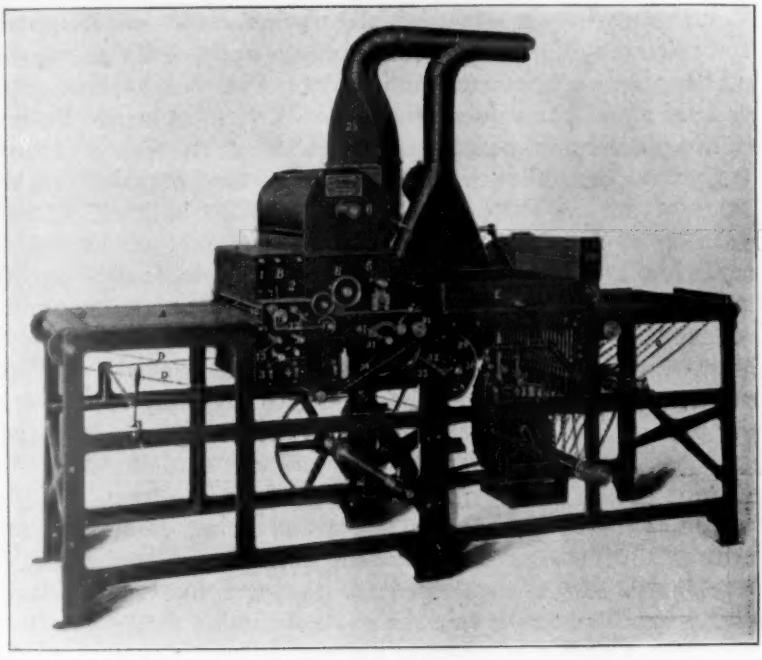


Fig. 1. Etch Powdering Machine. Front and Working Side.

the distribution of the powder, the clearing of the surface and the heating of the plate.

But after the plate has been etched to a depth where the sides of the projecting lines or other features of the design require to be protected as well as their surfaces, the proceeding becomes more complicated. This may be effected by the so-called "rolling-up" process, which consists of passing over the wetted surface of the plate a roller carrying a fatty ink, which, while rejected by the moist surface, adheres to the re-

sinous covering of the design. After being dried, the plate, with its fresh supply of ink, is again covered with the resinous powder, so prepared as to be limpid when fused; the surplus is blown away with a bellows and the adhering powder melted and allowed to run down over the edges of the projecting lines upon their sides. The plate is then again etched and the process repeated, usually five or six times, until the required depth has been reached. This method, known in this country as the European process, is still extensively in vogue on the Continent, where it was originally worked out. In 1881, while I was employing this process commercially, I hit, or to be, perhaps, more accurate, stumbled on the idea of laying the powder against the sides of the lines with a flat brush, melting it into place, and repeating the operation in the four directions at right angles across the plate. This method of protecting the sides of the lines proved more expeditions in itself, and by packing a considerable bank of the powder against them afforded an amount of resistance to the acid that permitted the successive etchings to be continued to a greater depth, and so reduce their number by half. With the growth of the photo-engraving industry at that period, when the swelled and wash-out gelatine methods were beginning to give way to the etching process, the four-way powdering method gradually spread into general use in this country, and came to be known in Europe as the American process.

The four-way powdering operation, being essentially mechanical in its nature, clearly lent itself to the application of machinery. As a supplement to the acid blast particularly, such a mechanism became the more desirable as the action of the blast, being mechanically uniform over the surface of the plate, required that the powdering of the design to prepare the plate for the action of the acid, be likewise accurately uniform over the entire surface.

On a small plate a trained and skillful hand can lay the powder evenly enough for all practical purposes, but when the plate is as large as a newspaper page, and especially when the brushing has to be done in the hurry and rush of a newspaper etching room, the work is inevitably more or less notably defective. Such plates, whether etched in the tub or in the blast, have here and there to be "cleared," that is, the in-

equalities of the powdering have to be reduced by dint of local etching with a brush.

Besides this technical consideration in favor of powdering by machinery there was also the want, not to say the need, of some means of relieving the operator from the strain of handling these large plates and from having to work in a powder-laden atmosphere while brushing them. The saving of time in the work, particularly with the larger plates, and still more where these are of double thick gauge or thicker, and correspondingly heavy, afforded but another reason for the use of machinery in powdering them.

Accordingly, in 1898, I began the construction of a mechanism for the purpose. The problem presented by it appeared simple enough at the start, but proved to be complicated by the necessity of making provision for the variations in the "packing" quality of powdered dragon's blood (which is the preferable resinoid for the purpose), under changes of the temperature and the moisture of the atmosphere. The first machine, completed in 1899, was succeeded by one after another of several modifications of the original design, but since October, 1903, a perfected machine has been in successful operation in the works of the Boston *Herald*. A number of others have since been put to work, notably at the St. Louis *Republic*, the New York *Journal* and the Philadelphia *Press*, each, however, modified in minor details to meet some special requirement.

The machine is represented in the accompanying autoglyphs and diagrams. It takes a plate of any size up to 24 inches square, which, if not thicker than the customary sixteen gauge, can be "topped," that is to say, prepared for the first etch, in one and one-quarter minutes. Thicker plates require correspondingly more time in the heating and cooling.

The "banking" of the powder, whether "wide" or "close," being primarily dependent on the nature and condition of the powder in use, is controlled by means of a movable handle, which determines the position of the brushes in relation to the plate and the degree of their pressure upon it. Apart from this preliminary adjustment, the process is entirely automatic.

The plate to be powdered is laid on the receiving table, face up, against the projecting prongs of a carrier bar; the machine is then started; a small handle is next pressed down to bring

the cylindrical feed-brush into operation; the plate is now carried forward by the carrier-bar under the feed-brush, thence onward under a gang of elliptically-moving flat brushes which pack the powder on the plate and clear away the surplus, still forward through a gas furnace which melts the powder in place, and finally on to a cooling table, where the hot plate is swept on both sides by an air blast, which quickly cools it in readiness for

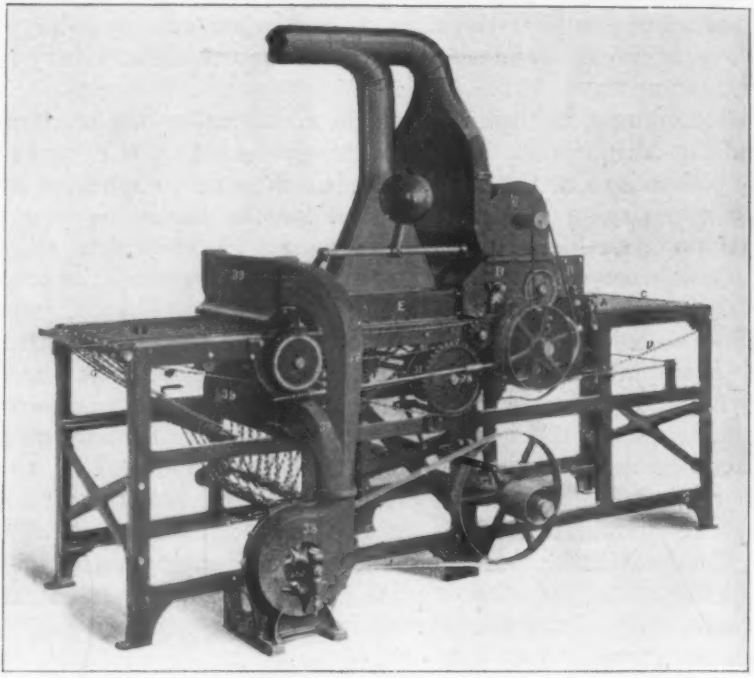


Fig. 2. Etch Powdering Machine. Back and Driving Side.

a repetition of the proceeding in another direction through the machine.

Putting the plate on its proper position on the receiving table, adjusting the gang brushes if necessary, starting the machine to go and bringing the feed-brush into operation is all the etcher has to do. When the plate passes the feed-brush the latter is automatically lifted out of operation; when it reaches the furnace the gas is automatically turned on and lighted; when it arrives at the cooling table the air blast is automatically started; when it emerges from the furnace the gas

is automatically cut off, and when the plate is cooled to a proper temperature the air blast ceases and the machine automatically stops. By this time, seventy-five seconds from the starting, the carrier-bar is back in its place at the front of the machine and the plate is ready for the next operation.

The furnace of the machine can be used by itself, independently of the rest of the mechanism, by turning on the gas through a lever-handle cock on a by-pass. The cover of the furnace is hinged, so it can be raised to take in a plate to be warmed or dried.

DETAILS OF THE MACHINE.

The plate is carried from the receiving table, A, through the powdering compartments, B, B, by means of the carrier-bar, C, attached to two sprocket chains, D, D. The carrier pushes the plate into the gas furnace, E, upon a train of sprocket chains, F, which, along with another similar train, G, carry the plate out upon the delivery table at the further end of the machine.

The powdering apparatus embraces principally the powder feed hopper, 1, the sweep-brush chamber, 2; the surplus powder receptacles, 3, 4; the gang-brush chamber, 5, and the fan chamber, 6. One side of the hopper-wall is movable on a pivot, 7, and held in place by a clamp, 8. This movable side abuts below against the surface of a feed screw, 9, which closes the outlet of the hopper.

The feed screw delivers the powder against the cylindrical feed-brush, 10, which revolves in a direction against the movement of the plate. It is operated by the worm wheel, 11, fastened on its shaft end and engaging with the worm, 12.

This worm wheel is normally out of contact with the worm, leaving the feed-brush out of operation; it is brought into operation by pushing down the small lever, 13, which operates cams that pull the worm wheel into engagement with the worm.

The small levers, besides operating the cams as above, also actuate a shaft to which are attached two dog-levers, 14, one on each side of the mechanism. These levers are engaged by lugs, 15, on the carrier chain, 16, placed just in front of the carrier bars, 17, the lugs in passing pull the dog-levers forward and thus turn the shaft and the attached cams sufficiently to

lift the worm wheel of the feed-brush out of engagement with the worm, placing the feed-brush out of operation and allowing the carrier bar to pass freely under it.

After receiving powder from the feed-brush, the plate passes under the sweep-brush, 2a, which packs the powder against the projecting features of the plate and sweeps back the surplus until it falls off into the drawers, 3, 4, below. From these receptacles, it is to be put back into the feed-hopper for further use.

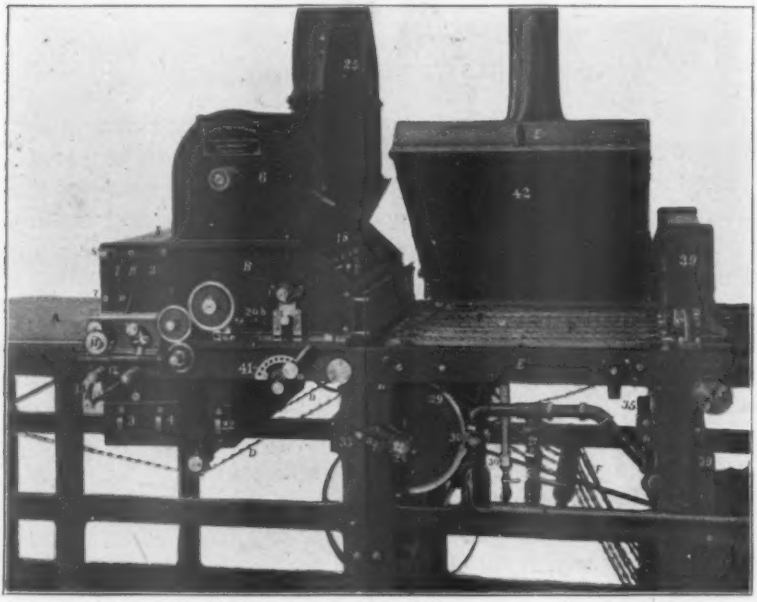


Fig. 8. Etch Powdering Machine. Powdering Compartment and Furnace.

The plate is carried beyond the feed-hopper into the gang-brush chamber, where the powder placed against the sides of the lines by the feed- and sweep-brushes is further packed in place and the surplus brushed off by the gang brushes, 18. There are six of these brushes, carried on two link belts around sprocket wheels in an elliptical orbit over the plate. The sprockets on the first shaft, 19, have recessed depressions, which permit the brushes, in their first contact with the plate, to drag over it at an angle, while on their last contact, under the second sprockets, 20, they are held over the plate vertically.

The shaft of the first sprockets is movable vertically, 20a, to adjust the pressure of the brushes in their first contact with the plate, and it is also movable laterally, 20b, so as to adjust the tension of the link belts and thereby the angle of the brushes as they pass over the plate. This tension, however, is not to be changed except as the wear of the brushes may make it necessary. The shaft of the second sprockets is movable up

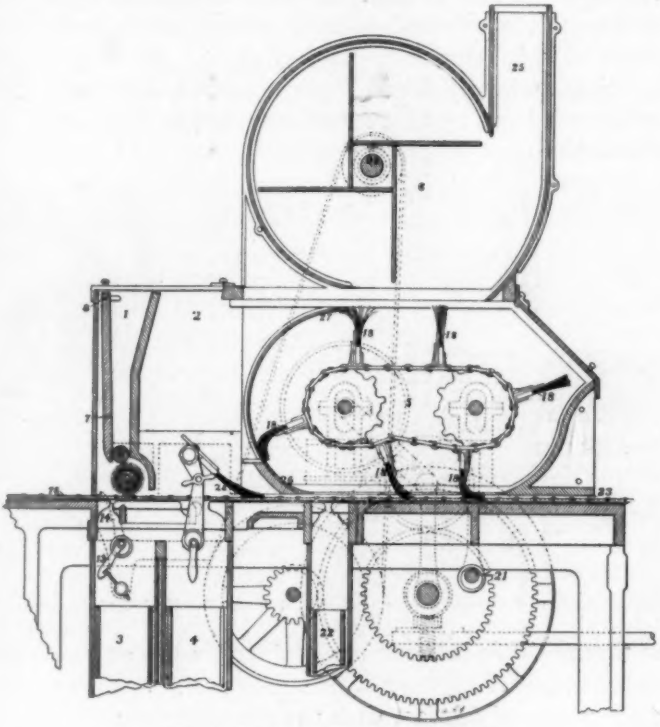


Fig. 4. Section of Powdering Apparatus.

and down, and adjustable by means of a hand-lever, 21, so that the "bank" produced by the final contact of the brush on the passing plate can be varied as desired.

The surplus powder brushed off from the plate by the gang brushes falls down into a drawer, 22, whence it is to be taken, sieved and used over again in the hoppers.

The revolution of the gang-brushes draws a current of air inwards through the exit opening, 23, over the surface of the

plate as it emerges from the brush chamber. This draft of air prevents any fine particles of powder from settling on the plate and leaves the ground perfectly clear. The air thus drawn in is carried around by the brushes and is taken up, together with its floating powder particles, and driven out by the rotary fan, 24, up through the ventilating chimney, 25.

The gang-brushes in their course over the passing plate are lifted from its surface in their inclined position by contact with the brake surface, 26, and carried around against the curved extension of this surface to its end at 27. At this point the brush being suddenly freed from restraint, the hairs spring forward, spread out and throw off any surplus powder remain-

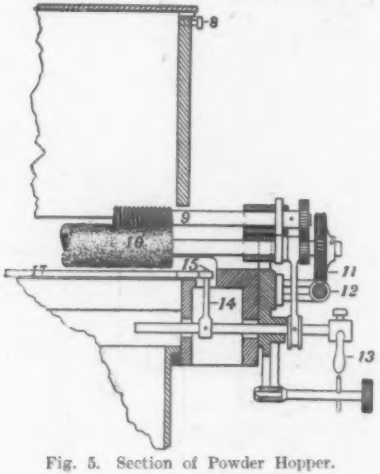


Fig. 5. Section of Powder Hopper.

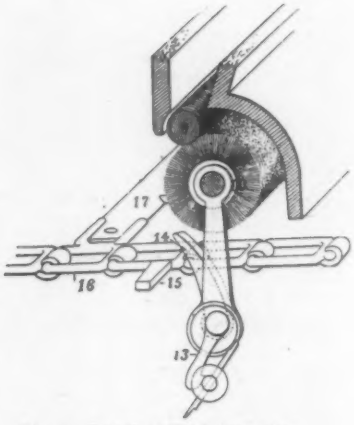


Fig. 6. Detail of Feed Apparatus.

ing on them. This is taken up by the air current produced by the rotary fan, leaving the brushes practically clean as they revolve into renewed contact with the passing plate.

To prevent an accumulation of powder against the edge of the advancing plate, the table over which the plate is carried forward under the gang-brushes is provided with two depressions, traversing the surface diagonally in divergent directions, like a V. As the moving plate passes over these depressions, the powder collected against the front edges of the plate is brushed down into the hollows, and after the plate has passed the powder is swept out of these back to the opening under the brake and down into the drawer, 22, below.

The control shaft, 28, makes one revolution while the machine completes its cycle. It carries a mutilated gear wheel, 29, which engages a pinion on the gas cock, 30, and alternately turns on and shuts off the gas supply; also a cam, 31, which actuates the belt shifter that alternately starts and stops the air blower; also the pivoted latch lifter, 32, which, in due course, lifts the belt shifting bar, 33, and lets the spring, 34, pull it back to stop the machine. These appliances are adjusted on the control shaft in such relation as to perform their functions in proper sequence.

The remaining features of the machine, such as the gas pipes, 35, the pilot light, 36, the by-pass and cock, 37, for independent use of the furnace, the rotary air blower, 38, and its distributing connections, 39, the ribbed delivery table, 40, &c., are sufficiently indicated in the illustrations and need no detailed description.

THE PRODUCTION OF BORAX IN 1904.

The production, imports, uses, and technology of borax are interestingly described by Mr. Charles G. Yale in a report on the borax industry in 1904, written for the United States Geological Survey.

All the output of borax in the United States comes from California, and the larger part of that from the extensive colemanite deposits in San Bernardino County. The total product for the year 1904 amounted to 45,647 tons crude, valued at $698,810. Of this amount 38,000 tons, valued at $508,000, came from San Bernardino County, Cal., the remainder coming from Ventura and Inyo Counties. In 1903 the returns gave an aggregate production of crude amounting to 34,430 short tons, valued at $661,400. The production in 1902 was 17,404 short tons of refined borax, valued at $2, 447,614, of which 862 short tons, valued at $150,000, were stated to be boric acid, and 2600 short tons of crude borax, valued at $91,000, a total of 20,004 short tons, valued at $2,538,614.

The amount of borax imported in to the United States in 1904 was 153,952 pounds, valued at $10,569. Borates, both the calcium and sodium, were imported to the amount of 89,447 pounds, worth $6,630. The quantity of boric acid imported is given as 708,815 pounds, valued at $27,658.

An interesting feature of Mr. Yale's report is a description of the Blumenberg sulphur-dioxide process, which is used by the American Borax Company at Daggart, Cal. Other processes for the manufacture of boric acid from colemanite have been described in previous Survey Reports. These include the Moore process, hydrochloric-acid process, sulphuric-acid process, and Bigott process.

Mr. Yale's paper is published as an extract from the Survey's annual volume "Mining Resources of the United States, 1904."

THE PRODUCTION OF BROMINE IN 1904.

The superior activity of American manufacturers has made for the bromine industry of the United States a place on the European market. The great deposits of haloid salts at Stassfurt and Leopoldshall in Germany are capable of supplying an almost unlimited market, but the American product has nevertheless forced itself into recognition. The result is that German manufacturers have been obliged to offer their goods in America at a price far below that usually current. Hence the price of bromide of potassium has fallen from twenty-five cents to fifteen cents a pound.

American bromine is obtained chiefly from salt brines in Michigan, West Virginia, Ohio and Pennsylvania. The manufacture of bromine in the United States was begun in 1846, at Freeport, Pa., but subsequently has been carried on chiefly in certain areas of brine production, which are mainly at or near Lake St. Louis, Mich., Pomeroy, Ohio, and Malden, W. Va.

To produce bromine the residual liquids or bitterns from the processes of salt manufacture are treated with sulphuric acid, thus forming hydrobromic acid. From this the bromine is separated by the use of an oxidizing agent which removes the hydrogen. For this purpose either chlorate of potash or binoxide of manganese is used.

Bromine is used by manufacturing chemists, who make from it the bromides of potassium, sodium, and ammonium used for medicinal purposes and as photographic reagents. A small amount of bromine is also used in the preparation of the coal tar colors, known as "Eosine" and "Hoffmann's blue." It is employed also as a chemical reagent for precipitating manganese from acetic acid solution, for the conversion of arsenious into arsenic acid, and for detecting nickel in the presence of cobalt in a potassium cyanide solution. Bromine dissolved in water may also be used as a disinfectant. Interesting metallurgical results have been obtained from its use in the bromination and bromocyanide processes of gold extraction, which may, in a measure, become substitutes for chlorination and cyanidation.

The total output of American bromine in twenty-five years has been 10,499,625 pounds, valued approximately at $2,887,917. During 1904 the total output amounted to 897,100 pounds, valued at $269,130. Germany furnishes annually about 300 tons of bromine.

The above facts are taken from a report on the production of bromine in 1904, which Mr. Frederick J. H. Merrill has written for the United States Geological Survey. It is published as an extract from the annual volume "Mineral Resources of the United States, 1904," and may be obtained on application to the Director of the Geological Survey, Washington, D. C.

STEEL, with one-quarter per cent. C, one per cent. W, two-fifths per cent. Mn and one-quarter per cent. V, broke at 112,540 pounds per square inch.

Rondinella's Photo-Printing Machine.

[*Being the Report of the Franklin Institute, through its Committee on Science and the Arts, on the invention of Prof. L. F. Rondinella, of Philadelphia. Sub-Committee: L. E. Levy, Chairman; Henry R. Heyl, Waldemar Lee, Thos. P. Conard.*]

No. 2357.

The Franklin Institute, acting through its Committee on Science and the Arts, investigating the merits of the "Photo-Printing Machine," by Prof. L. F. Rondinella, of Philadelphia, Pa., reports as follows:

This is an apparatus for producing photographic prints in continuous form from tracings or other flexible transparencies of unusual length.

The form of the apparatus under present consideration, to which the inventor has given the name of "Star Photo-Printing Machine," is designed especially for the practice of the blue-print and paper-negative processes, and was patented March 19, 1901, No. 670,349. The machine is adapted to print by sunlight or artificial light as may be most convenient, and accordingly comprises two independent parts, the printing machine proper and the electric lighting apparatus upon which it is supported.

The printing mechanism is contained in a casing which is provided with ball casters so as to be easily rolled out from its support upon tracks arranged for the purpose through a window for sun-printing. The casing is made of well-finished oak and contains all the requisite materials of the printing process throughout and also all the mechanism of the apparatus except the small electric driving motor and its reducing gears. These are fixed on the exterior, on one side of the machine. The casing is curved on top, whence it runs down into a slant of about 45° and then projects to form a receiving compartment at the front. The covers of the slanting and horizontal parts are hinged together and to the front edge of the casing,

forming a two-leaved lid which, when lifted and brought forward, opens the machine and at the same time forms a projecting work table. This hinged cover may also be brought to rest in two other positions, leaving the machine only partially open and the work table out of the way. The curved section of the casing is covered with a roll-top shutter which serves as a covering slide over the exposure opening, permitting this to be varied in extent up to 105° for rays from the sun and up to 120° or more for those from the electric lamps.

The printing is effected through a transparent covering-sheet which holds the tracing and sensitive paper down upon the surface of a felt-covered drum that revolves under the ex-

Fig. 1.—Star Photo-Printing Machine, with Casing Closed.

posure opening concentrically with the curved top of the casing. The transparent cover consists of a strip of the best tracing cloth over seventy feet in length, permanently fastened at one end to the drum and passing around this to a winding roll under proper tension. The tracing cloth is carefully prepared so as to wind true from roll to drum and back again, and its edge is spaced off into feet and marked with numbers which indicate the maximum length of print which may yet be made when part of the cover has been wound off. The cover-strip passes from its winding-roll up under an idler and then around this down to its contact with the drum, the material thus forming an inclined feed-apron down which the tracing and sensitive paper are carried into contact with the revolving drum, and

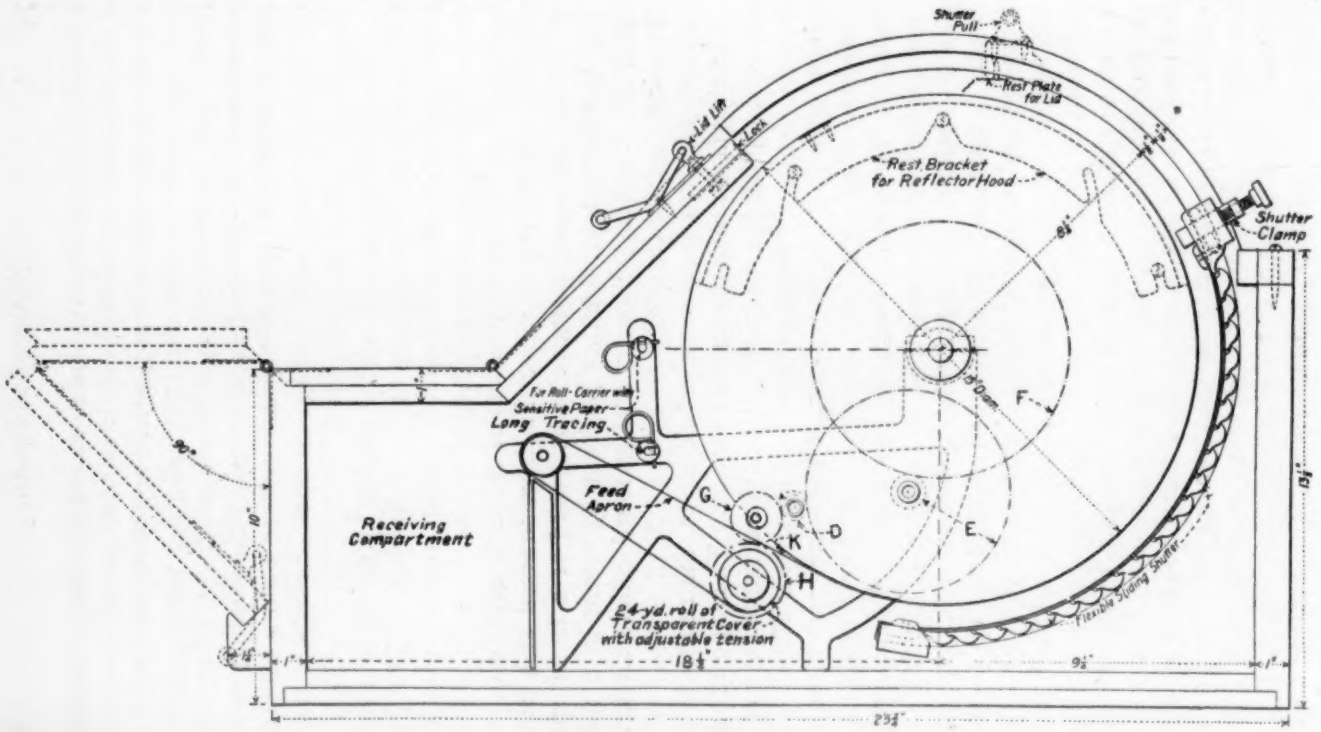


Fig. 2.—Star Photo-Printing Machine, End View of Inside Mechanism.

thence around with it under the exposure opening. The printing is continued on the return of the drum, and after the printing the tracing and prints are carried up the inclined plane and delivered over the idler into the receiving compartment in front. The tension of the transparent cover can be regulated by means of a friction brake at one end of the winding roll and can be effectively controlled so as to insure a close contact of the sensitized paper with tracings on thick or rumpled tracing cloth at any desired printing speed.

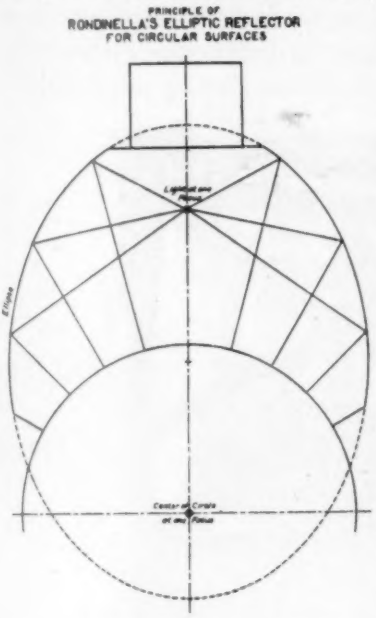
The drum is actuated from the outside by means of a reducing gear-couple from the motor to a driving spindle which passes into the casing and carries a small pinion on its inner end. This spindle is movable laterally so as to carry the pinion into mesh with either of two sets of reducing gears on the inside, one set serving to move the drum forward at a certain speed and the other to move it backward at a faster speed. The spindle is held in either position by means of a spring catch which fits into either of two grooved collars carried by the spindle on the outside.

Three different speeds are provided for, the return in such case being faster than the forward motion. The exposure goes on during both the forward and backward movement of the drum. The combination of these various speeds affords a gradation of nine different periods of exposure, and these may furthermore be varied by changing the lamp resistance attached to the motor. The use of cone pulleys or of an external rheostat for this purpose is thus advantageously avoided.

The machine, together with its electric-light supporting frame, is built in three widths, affording prints up to thirty, forty-two and forty-eight inches wide respectively, all three being adapted to make continuous prints up to a length of seventy feet.

The electric-light Support of this machine, though an extraneous feature of the apparatus, must yet in view of the practical requirements of any considerable drafting room or of a commercial blue-printing establishment, be regarded as of primary importance. The support is so wired as to be ready for connection to the mains of either a two- or three-wire system carrying 110 or 220 volts, direct current. The lighting arrange-

ment consists of enclosed-arc lamps, four, five or six of them for the three respective widths of the machine, or of a set of three or four Coper-Hewitt mercury lamps of the requisite length.



[Fig. 4—For Uniform Distribution of Electric Light

The most actinic rays of light from an arc lamp radiate in a beam outward and downward from the crater formed by the arc in the upper carbon, and the idea is to so reflect all the rays as to bring about a zone of uniform actinic force over the entire surface of the exposure opening of the machine. To this end the lamps are placed directly over the axis of the drum, under a reflector-hood especially designed for the purpose upon the principle of reflection from the surface of an ellipse, as first demonstrated by the present inventor before the Franklin Institute, at its meeting on December 21, 1904. The lamp and the enclosing reflector-hood are both hung from a suspension beam adapted to be raised and lowered on the support over the machine, the lamps being held to the beam in a fiixed position and the hood by chains that permit its being raised and lowered about the lamps. Through sight-holes placed for the purpose the hood can be adjusted over the lamps so that the arcs coincide with the focal line of the elliptical inner surface of the hood. In this position all the rays that strike the inner surface are reflected towards the opposite focus of the ellipse. The suspension beam with its lamps and hood is then lowered until the ends of the reflector hood rests upon the brackets at the two ends of the machine casing. Thus placed, the reflected light is intercepted by the cylindrical surface of the drum, reaching it and its overlying tracing and sensitized paper in rays of equal length and in directions uni-

formly normal to the surface, thus producing the desired area of uniform illumination. For the long tubes of the mercury lamps, the same principle is applied in a form modified for the purpose. In either case the uniformity of illumination which is produced is such that tracings coming within the area of the opening can be effectively printed without moving the drum.

Fig. 3.—Support for Star Photo-Printing Machine, and Electric Equipment.

The Rondinella Photo-Printing Machine marks a distinct advance in the practice of this art. Long prints, whether from negatives or from tracings, were formerly produced by simply pasting shorter ones together or by the obviously difficult and unsatisfactory method of making the continuous print by suc-

cessive exposures of shorter sections. To obviate the imperfections inevitable in either of these processes, various expedients have been resorted to, one method being to fasten the sensitized paper with its over-lying flexible transparency on a board of sufficient size in width and length, springing the board lengthwise to force the material into the best possible contact

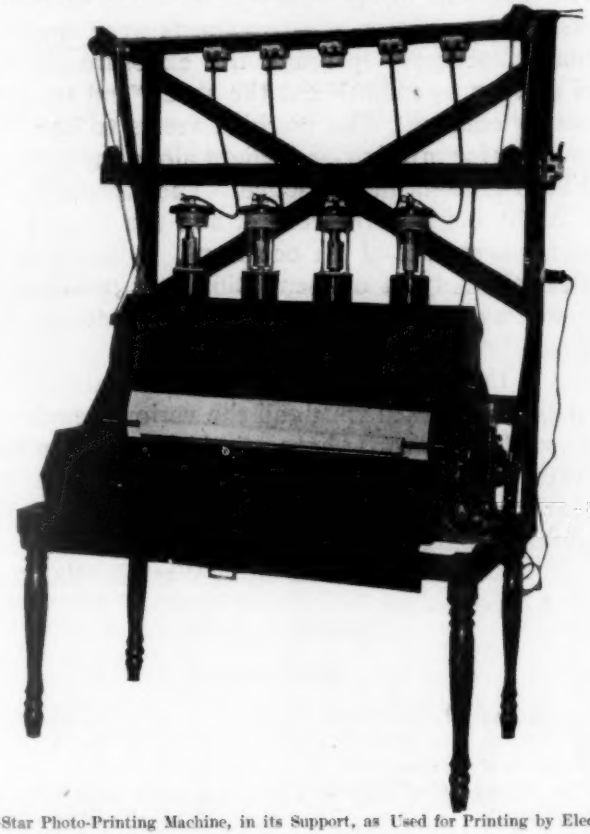


Fig. 5.—Star Photo-Printing Machine, in its Support, as Used for Printing by Electric Arcs.

over the convex surface and then exposing to as even light as possible. An effort to replace these crude procedures with a mechanism for the purpose was made some fourteen years ago by Paul Heinze, of Chicago, Ill., whose invention was patented No. 469,244, on February 23, 1892. In that device the tracing and sensitized paper were each to be separately rolled upon spools from which they were then drawn off together by the

rotation of a drum to which the outer ends of both were fastened. These spools were geared so as to make the same number of revolutions, but on account of the different thicknesses of the two materials, the diameters of the two rolls would be or would soon become different, and unequal lengths of the two materials would be drawn off in the same time. In the course of the rotation, the two sheets were drawn under a succession of scrapers spanning the exposure opening, the scrapers serving to smooth out the sheets and to force them into printing contact. The machine seems to have been devised especially for printing by daylight alone and appears never to have been brought into practice. The Rondinella machine of 1901 is the next on the record, and the first to meet the practical requirements of the occasion. It has been followed by several others, most of them utilizing a rotating drum on which to effect the exposures, but manifestly retains its leading place as an efficient solution of the problem.

In view of the scientific accuracy and mechanical thoroughness and simplicity with which all the various requirements of the process of continuous photo-printing have been fulfilled in this machine, the Franklin Institute recommends the award of the John Scott Legacy Premium and Medal to the inventor, Prof. Lino F. Rondinella, of Philadelphia, Pa.

Attest, WM. H. WAHL, *Sec'y.*

Adopted June 7, 1905.

Sections.

MECHANICAL AND ENGINEERING SECTION. *Stated Meeting*, held Thursday, November 16, 8 P.M. Mr. James Christie in the chair. Present, thirty members and visitors.

Prof. H. W. Spangler read an illustrated paper describing some experiments on heating the Dormitories of the University of Pennsylvania.

Mr. Arthur Falkenau followed with some Notes on the Use of Materials in Hydraulic Machinery.

Both papers were freely discussed. The meeting passed a vote of thanks to the speakers of the evening and adjourned.

FRANCIS HEAD, *Sec'y.*

SECTION OF MINING AND METALLURGY. *Stated Meeting*, held Thursday, November 23, 8 P.M. Prof. A. E. Outerbridge, Jr., in the chair. Present, thirty-seven members and visitors.

The chairman introduced Mr. Clifford Richardson, of New York, who

presented an interesting and instructive communication on the Constitution of Portland Cement.

The paper was discussed by Mr. Robt. W. Lesley, Dr. W. J. Williams, Dr. Wm. H. Wahl and the author.

The thanks of the meeting were voted to the speaker of the evening. Adjourned.

WM. H. WAHL, *Sec'y pro tem.*

Franklin Institute.

Proceedings of the Stated Meeting held Wednesday, December 20, 1905.

HALL OF THE FRANKLIN INSTITUTE,
Philadelphia, December 20, 1905.

President JOHN BERKINBINE in the chair.

Present, fifty-two members and visitors.

Additions to membership since last month, fifteen.

The Secretary presented the resignation from the Board of Managers and the Committee on Science and the Arts, of Dr. Coleman Sellers. Mr. H. R. Heyl, Mr. L. E. Levy, the President and the Secretary referred in complimentary terms to the long and eminent service which Dr. Sellers had rendered to the Institute during his long association with it; whereupon the following resolution, offered by Vice-President Washington Jones, and seconded by H. R. Heyl, was unanimously adopted:

Resolved, That the Franklin Institute in accepting the resignation of Dr. Coleman Sellers from membership on the Board of Managers, the Committee on Science and the Arts, and the Committee on Publications, directs that a minute be entered on its records expressive of its high appreciation of, and grateful thanks for his long and valued services to the Institute, as President, manager and committeeman.

The Secretary was directed to transmit a copy of this resolution to Dr. Sellers.

The following nominations were then presented for officers, managers and committeemen to be voted for at the annual election, to be held on Wednesday, January 17th, 1906, viz.:

For President	(to serve one year).....	JOHN BIRKINBINE.
" *Vice-President*	(" three years).....	JAMES M. DODGE.
" *Secretary*	(" one year).....	WM. H. WAHL.
" *Treasurer*	(" ").....	SAMUEL SARTAIN.
" *Auditor*	(" three years).....	W. O. GRIGGS.
" *Auditor*	(" one year).....	SAMUEL P. SADTLER.

For *Managers* (to serve three years).

CYRUS BORGNER,	JAWOOD LUKENS,
JAMES CHRISTIE,	LAWRENCE T. PAUL,
PERSIFOR FRAZER,	HORACE PETTIT,
HARRY W. JAYNE,	OTTO C. WOLF,

WM. H. LAMBERT (to serve for two years).

For *the Committee on Science and the Arts* (to serve three years)

Richard L. Binder,	Arthur Falkenau,	W. N. Jennings,
Henry F. Colvin,	John M. Hartman,	H. F. Keller,
Thos. P. Conard,	C. C. Heyl,	Louis E. Levy,
Geo. S. Cullen,	Henry R. Heyl,	Tinius Olsen,
Charles Day,	George A. Hoadley,	Chas. E. Ronaldson,
J. M. Emanuel,	Richard L. Humphrey,	Sam'l P. Sadtler,
Ernest M. White,		W. J. Williams.

C. A. Hall (to serve for two years). Wilhelm Vogt (to serve for one year).

The President then introduced Mr. Howard DuBois, Mining Engineer, Philadelphia, who presented a communication, profusely illustrated with lantern photographs, on "Hydraulic Mining in British Columbia and Alaska."

The thanks of the meeting were voted to the speaker. Adjourned.

Wm. H. Wahl, *Secretary.*

Committee on Science and the Arts.

(Abstract of Proceedings of the stated meeting held Wednesday, December 6th.)

Dr. Edward Goldsmith in the chair.

The Committee adopted the following reports:

(No. 2372.) *New Physical Diagnostic and Surgical Instruments.* Dr. Henry Emerson Wetherill, Philadelphia.

Abstract: These instruments are in part protected by U. S. Letetrs patent (No. 780,315, January 17, 1905, and No. 798,938, September 5, 1905). They consist of a medical hygroscope, called by the inventor the Hygromed, which has for its object the detection of the amount of moisture in the skin; an improved precipitating device, called generically the Hæmatokrit, for the separation and precipitation in a graduated tube of the contained solids in the liquid treated—a compact, portable and handy device for its intended use; an ingenious pair of scissors, combining in one seven different instruments.

The report awards the Edward Longstreth Medal of Merit to the inventor. (*Sub-Committee*, Dr. W. O. Griggs, Chairman; Dr. W. J. Williams.)

(No. 2377.) *Automatic Momentum Car-Brake.* Wm. L. Barker, Llanerch, Pa. An advisory report.

The following reports passed first reading:

(No. 2365.) *"Speed-Jack."* C. J. Reed, Philadelphia.

(No. 2375.) *Quartz-Glass Mercury Lamp.* W. C. Heraeus, Hanau, Germany.

(No. 2336.) *System of Wireless Telegraphy.* Dr. Lee De Forrest, New York.

The following protests were disposed of:

(No. 2216.)*Narnst Lamp.* Protest of F. M. F. Cazin, Hoboken, N. J.

(No. 2360.) *Ives's Diffraction Grating Replicas.* Protest of R. James Wallace, Yerkes Observatory, University of Chicago.

The protests were not sustained.

Wm. H. Wahl, *Secretary.*